THE WEATHER AND CIRCULATION OF OCTOBER 1957 [1]

A Month with a Record Low Zonal Index for October in the Western Hemisphere

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1. BLOCKING AND LOW INDEX

Blocking and low zonal index were dominant features of the circulation during October 1957. That this was a continuation of a longer-period trend is indicated by table 1, which lists 30-day mean values of the 700-mb. zonal index for each month of 1957. This parameter, which expresses the strength of the temperate-latitude westerlies averaged over the western half of the Northern Hemisphere, was below its corresponding normal value for seven of the first ten months of the year.

A reflection of the anomalous nature of the circulation for the year is the fact that Billings, Mont., Pueblo and Denver, Colo., Dallas, Tex., and Tampa, Fla., each recorded more precipitation during the first ten months of 1957 than had been recorded at these stations during any previous calendar year of record. In sharp contrast, 10-month deficiencies in precipitation were the greatest of record at several locations in the Northeast [10].

Examination of the data in table 2 reveals that the zonal index for the mid-latitude westerlies at the 700-mb. level in the Western Hemisphere was at its lowest value for any October since comparable data were first computed in 1944. Willett [11] and Namias [6, 7] have described the general nature and chief characteristics of the low-index state. Many of these are to be found as features of the circulation for October 1957.

Concomitant with this state is the presence of high-latitude blocking or a split in the planetary westerlies. During October this blocking was entrenched most firmly over northern North America. The monthly mean chart at 700 mb. (fig. 1) shows the blocking as the ridge located over the Yukon and its attendant positive anomaly center of 350 ft. This anomaly was elongated east-southeastward with a second positive center of 260 ft. near Churchill on Hudson Bay.

The blocking character of the ridge over the northwestern portion of the continent of North America is seen quite clearly in the contours in figure 1, with a high-latitude ridge poised just north of the trough along the west coast of the United States. A portion of the broad band of westerlies in the central Pacific curved northward around the ridge, while the southern portion of the mid-Pacific westerlies curved southward through the trough along the California coast.

TABLE 1.—*Monthly mean values of the zonal index at 700 mb. (in meters per second) for the area 35° N.–55° N. and 5° W.–175° E.*

	1957	Normal	Departure from normal
January	10.6	11.8	−1.2
February	11.0	10.2	+.8
March	8.4	9.1	−.7
April	8.9	8.3	+.6
May	7.3	7.7	−.4
June	6.9	6.9	.0
July	6.8	7.2	−.4
August	6.6	6.8	−.2
September	7.2	7.8	−.6
October	7.3	9.5	−2.2

TABLE 2.—*Mean October values of the 700-mb. zonal index (in meters per second) for the area 35° N.–55° N., 5° W.–175° E., with normals and extremes*

Year	October zonal index	Departure from normal	Year	October zonal index	Departure from normal
1944	8.8	−0.7	1951	9.4	−0.1
1945	9.0	−.5	1952	10.4	+.9
1946	8.8	−.7	1953	9.8	+.3
1947	10.6	+1.1	1954	10.8	+1.3
1948	9.6	+.1	1955	9.8	+.3
1949	11.1	+1.6	1956	9.4	−.1
1950	11.0	+1.5	1957	7.3	−2.2

Normals (computed from [9]):
Normal for October: 9.5 m/sec.
Highest normal for any month: 11.8 m/sec. (January)
Lowest normal for any month: 6.8 m/sec. (August)
Extremes:
Highest observed index for any month since January 1944: 13.0 m/sec. (January 1946)
Lowest observed index for any month since January 1944: 6.0 m/sec. (May 1946, 1948, 1952)

This split in the westerlies and the resultant difluent region over British Columbia and adjacent Pacific waters locates the area of most pronounced blocking in the monthly mean pattern for October 1957. A second seat of blocking, weaker in character, may be seen near the 80th parallel north of Novaya Zemlya. The positive anomaly center of 140 feet was less intense and much smaller in area than its North American counterpart. The split in the westerlies associated with the block was also less pronounced. It is interesting to note the same out-of-phase relationship south of this block, with a middle-latitude trough extending southward through central Russia.

A minor closed anticyclone appears in figure 1 over Greenland, but it should be noted that no positive anomaly was associated with it. This cell was a remnant of blocking which persisted over the Greenland area throughout the period from May through September 1957 (see previous articles in this series). Above normal heights as-

[1] See Charts I–XVII following p. 256 for analyzed climatological data for the month.

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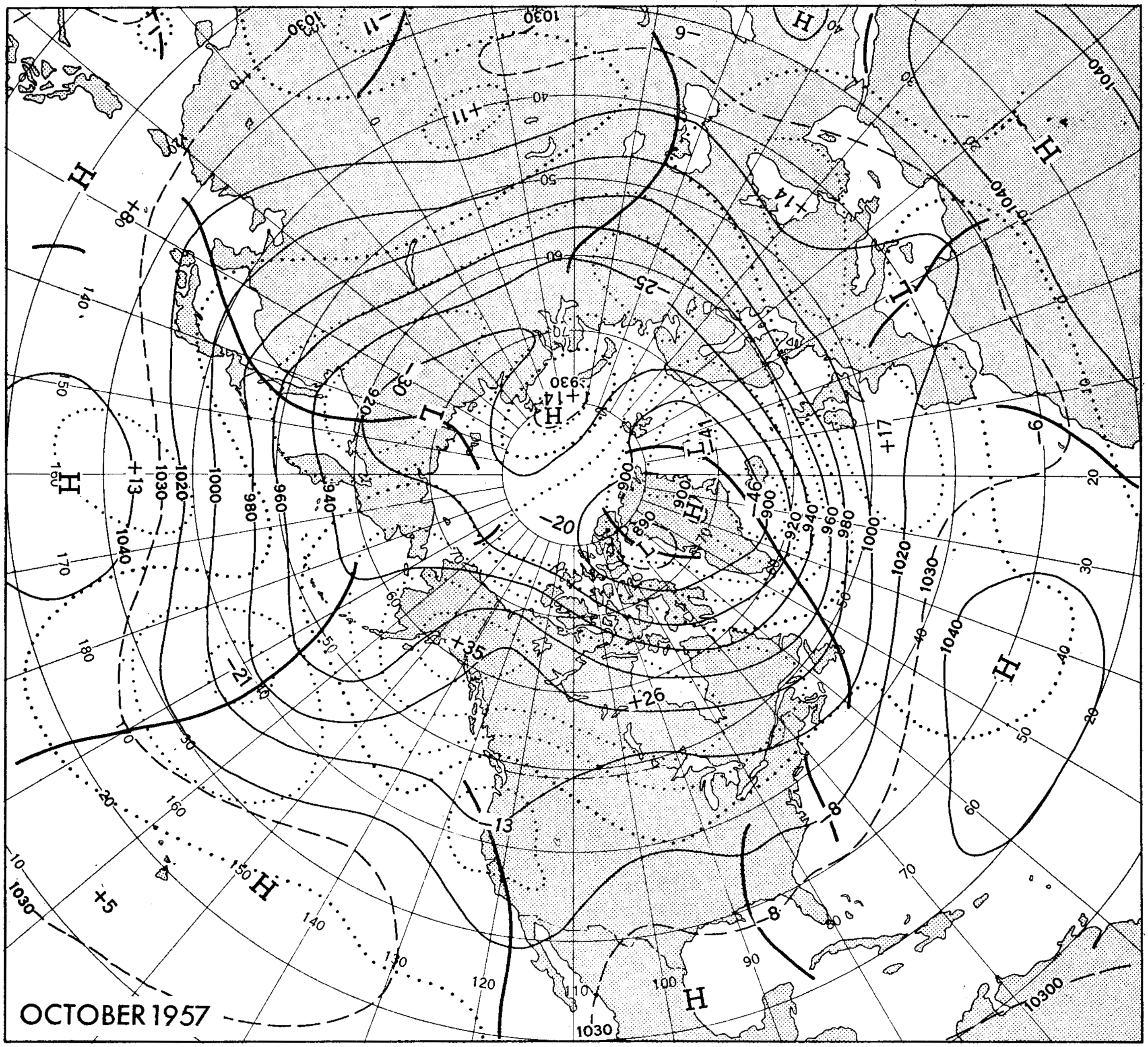

FIGURE 1.—Mean 700-mb. contours (solid) and departures from normal (dotted) (both in tens of feet) for October 1957. Note the difluent nature of the westerly current emanating from the Central Pacific and the blocking character of the DN field over North America, with resultant weak westerlies over the United States.

sociated with the blocking High weakened rapidly during the early part of October and then disappeared completely as rapid deepening took place east of Greenland during the second week of the month.

A number of other features also reflect blocking and low index in October 1957. Figure 2, a profile of the westerly wind component from 20° N. to 90° N. for the Western Hemisphere, shows below normal westerlies in middle latitudes with above normal westerlies in both polar and subtropical regions. Namias [6, 7] has noted a tendency for the total momentum of the mid-tropospheric westerlies to standardize about a small range of values for a given month. This concept is portrayed in figure 2. The area under the normal curve (dashed) can be thought of as proportional to the total momentum of the westerlies, while the actual profile (solid) represents the latitudinal distribution of this momentum during October 1957. The total area under the solid curve was very nearly the same as the area under the dashed curve, and therefore the total momentum for October was conserved. The latitudinal distribution of this momentum varied markedly from the normal distribution, however.

Mean geostrophic wind speed isotachs are shown in figures 3A and 4 for the 700- and 200-mb. levels, respectively. At 700-mb. the split in the mid-tropospheric jet stream along the west coast of the United States was well marked. Comparison with the normal jet stream for October (dashed) in this area shows a wind speed maximum from the central Pacific displaced progressively farther south of normal as it approached the west coast. There is weak but indecisive evidence in the original data from which the chart was drawn for continuing this axis of wind speed maximum across the United States near the 30th parallel, some 15°–18° south of its normal October latitude. A second wind speed maximum is present on figure 3A, beginning in northern Alaska and passing southeastward across Canada well north of normal. This split in the belt of strong westerlies over the North American continent was associated directly with the blocking character of the monthly mean circulation and was related to the anomalies of temperature and precipitation observed in the United States during October.

The contours and isotachs displayed in figure 4, the 200-mb. monthly mean chart for October, indicate the same general features as were observed at 700 mb., but in a less pronounced fashion. The split in the westerly stream along the west coast of North America was not as spectacular in the contour field at the 200-mb. level, but the isotach picture was comparable to that found at 700 mb., with a low-latitude jet stream across the United States and a second wind speed maximum at high latitudes.

Additional broad-scale features of the mean circulation for the month are observable in figures 1 and 3A. The largest anomaly of height at 700 mb. during October was the 460-ft. negative center located between Greenland and Iceland (fig. 1). This well-developed center of action was associated with faster than normal westerlies (fig. 3B) displaced north of normal (fig. 3A), as high index prevailed over the North Atlantic region during the month. It is interesting to speculate as to the probable relationship between the slower than normal middle-latitude westerlies associated with the North American block and the faster than normal westerlies and high index found over the Atlantic. The anomaly pattern in figure 1 is useful in rationalizing this relationship. The positive anomalies in height over Canada, especially those in central Canada, reflected an increase in the northwesterly flow over the Canadian archipelago. This flow conceivably transported more polar air than normal off the continent over the comparatively warm waters of the North Atlantic south of Greenland. As strong temperature gradients became established, baroclinic effects were probably related to the strong deepening which took place during the last three weeks of the month. Some measure of the intensity of the deepening is revealed by the fact that a daily system reached a sea level pressure close to 940 mb. on the 27th just to the northeast of Iceland. A second, and not completely independent, way of looking at the relationship between the circulation over North America and that over the Atlantic can be found by examination of the contour pattern over these regions in figure 1. As has been pointed out, the winds along the west coast of North America showed difluence as the westerly stream split to flow around a blocking High.

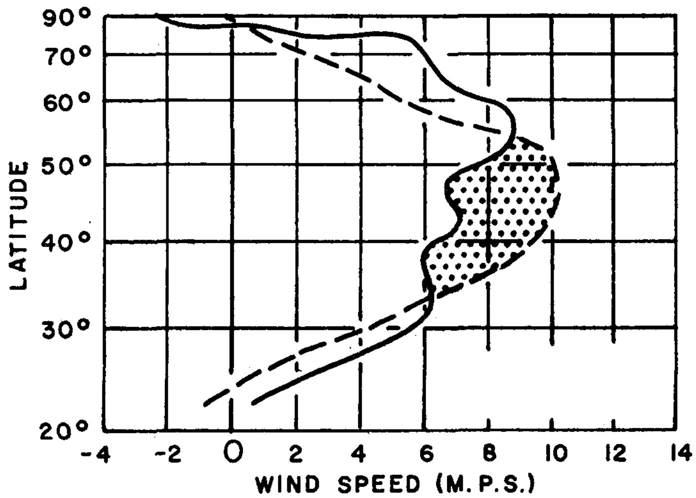

FIGURE 2.—Mean 700-mb. zonal wind speed profile for the Western Hemisphere for October 1957. The solid curve represents the observed and the dashed curve the normal for the month. Note how the decrease in speed of the middle-latitude westerlies was compensated for by an increase in the polar and subtropical westerlies, thereby tending to conserve the total momentum of the westerlies.

After passing around the block, the westerly current became confluent in character. Namias and Clapp [8] have discussed the mechanism for a speedup in the westerlies resulting from the type of confluent pattern portrayed off the east coast of the United States in figure 1 and implied in figure 3A.

In summary, then, the circulation of October 1957 was characterized by slower than normal 700-mb. westerlies over the eastern Pacific and most of North America. The belt of maximum winds was split over the continent with one belt displaced far to the south of normal and a second belt to the north of normal. A well-developed Icelandic Low and strong westerlies displaced north of normal were the main features of the circulation over the Atlantic.

2. THE MONTHLY CIRCULATION AND THE WEATHER ANOMALIES OVER THE UNITED STATES

The monthly anomalies of temperature and precipitation over the United States may now be related to the circulation picture. Charts I–B and III–B portray the departure of average temperature from normal and the percentage of normal precipitation for October 1957.

TEMPERATURE

Temperatures over nearly all the United States averaged below normal for the month. Table 3 lists a selected group of stations compiled to demonstrate the nearly nationwide extent of the abnormally cool temperatures. While only one station (Richmond, Va.) reported the month as the coldest October of record, the fact that much of the greater portion of the country experienced significantly below normal temperatures is a reflection of the abnormality of the mean circulation for the month.

The fact of unusually low index in the mid-latitude, upper-level westerlies indirectly indicates a mechanism

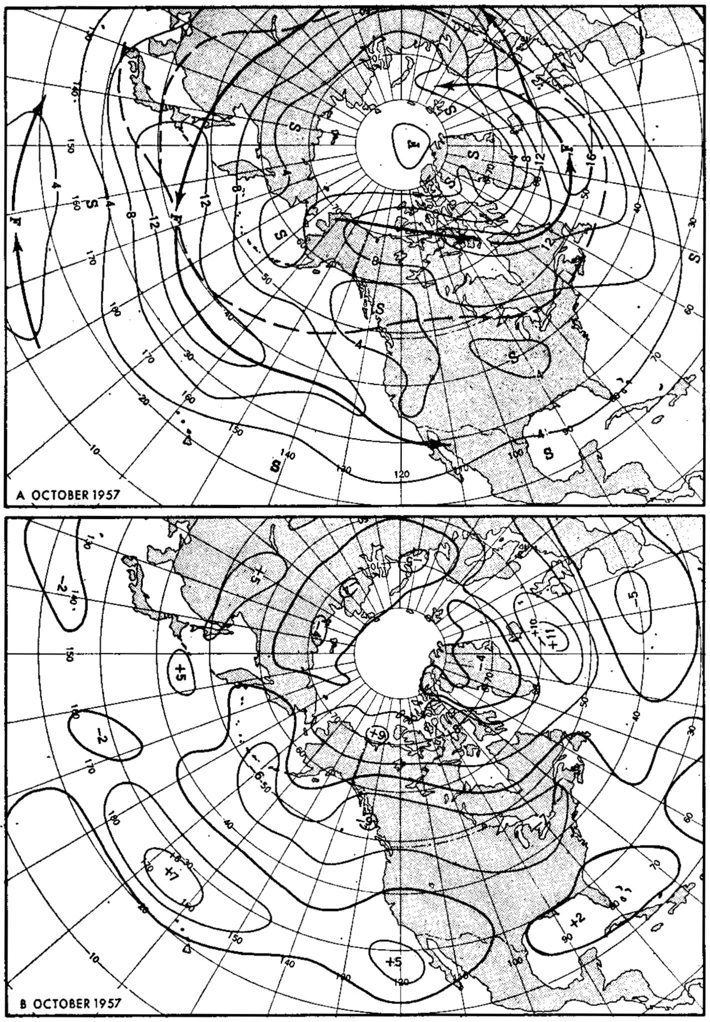

FIGURE 3.—(A) Mean 700-mb. geostrophic wind speed (meters per second) for October 1957, (B) Departure from normal of wind speeds shown in A (analyzed for 4 m/sec. except where otherwise indicated). Solid arrows indicate primary axis of 700-mb. jet stream and dashed arrows the normal October position.

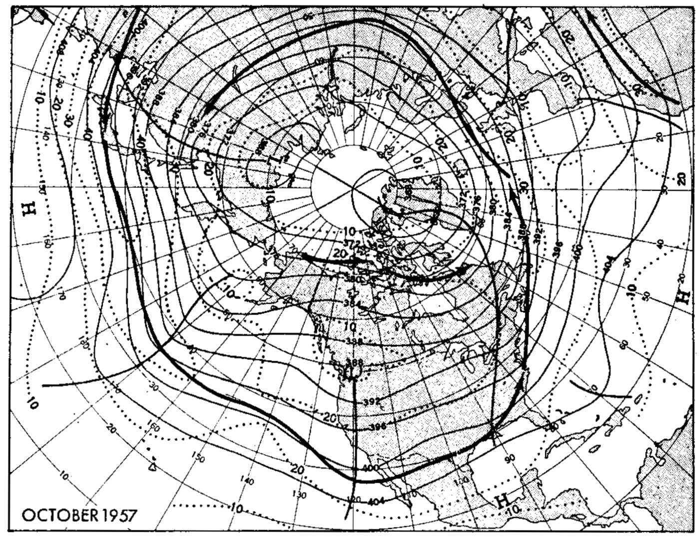

FIGURE 4.—Mean 200-mb. contours (solid, in hundreds of feet) and isotachs (dotted, in meters per second), for October 1957. Solid arrows give location of primary jet stream. A pronounced split in the jet stream over North America is evident.

for the deployment of polar air into the United States. A more direct indication may be found in figure 3A. The normal position of the jet stream at 700 mb. for October lies along the United States-Canadian border [4]. In this position the fast westerlies are effective in preventing meridional transport of polar anticyclones. Absence of a fast band of westerlies across the central portion of North America during October 1957, conversely, permitted periodic outbreaks of cold polar air over the country.

Comparison of the temperature anomalies depicted on Chart I–B and the departures from normal (DN) height (fig. 1) indicates a positive relationship between these two parameters over most of the country. Martin and Leight [5] found the positive correlation between these two parameters to be only moderately good during the fall season and obtained the poorest results along the west coast. During October 1957, the immediate coastal section of California and the Olympic Peninsula in Washington showed negative correlation (above normal surface temperatures and below normal 700-mb. heights). This underlines the importance of purely local effects and demonstrates the restraint necessary in attempting to relate all weather anomalies to broad-scale (both time and space) circulation patterns. In this particular area there is an apparent tendency for the coastal region temperature anomaly to be related inversely to that over the interior sections. This, in turn, has been associated with a strengthening of the sea breeze regime resulting in cool temperatures along the immediate coast when inland temperatures are above normal, with the reverse prevailing when interior temperatures are below normal.

Positive correlation exists between the above normal temperatures observed over New England in October and the above normal heights at 700 mb. It is difficult, however, to explain the above normal temperatures over New England on the basis of the sea level monthly mean

TABLE 3.—*Average monthly temperatures dand epartures from normal (°F.) for selected stations in the United States during October 1957*

	Temperature		Remarks
	October average	Departure	
FAR WEST			
Walla Walla, Wash	50.4	−4.8	Coldest October since 1919.
Red Bluff, Calif	60.0	−5.1	Coldest October since 1920.
GREAT PLAINS			
Omaha, Nebr	51.8	−3.7	5th coldest October since 1900.
El Paso, Tex	62.4	−2.8	Coldest October since 1912.
SOUTHEAST			
Fort Myers, Fla	73.6	−2.7	Equals coldest October since 1913.
Birmingham, Ala	58.5	−5.2	2d coldest October since 1900.
OHIO VALLEY			
Evansville, Ind	54.1	−5.2	4th coldest October in 61 years.
MIDDLE ATLANTIC			
Elkins, W. Va	46.9	−4.8	2d coldest October since 1900.
Richmond, Va	54.6	−4.2	Coldest October in 61 years.

chart (Chart XI) and its departure from normal for the month (Chart XI inset). These charts show a mean sea level flow from the northwest and a northerly anomalous flow for the month, and thus imply advection from a relatively cool source region. The answer to this apparent discrepancy may lie in the fact that mean virtual temperatures in the 1,000–700-mb. layer over eastern Canada averaged as much as 3°–4° above normal during the month, and therefore the flow depicted over New England on Chart XI was from a region that was warmer than normal during the month.

PRECIPITATION

The difficulty in relating a discontinuous phenomenon such as precipitation to a mean pattern is well known. Chart III–B can be related to the mean 700–mb. and sea level circulations (fig. 1 and Chart XI) only in a gross sense. The location and amplitude of the mean trough along the west coast of the United States may be assumed responsible for the production of the well above normal precipitation amounts observed over most of the western two-thirds of the nation (as much as 700 percent of normal in parts of Arizona and Colorado). West-northwesterly flow from the Continental Divide eastward across the northern third of the nation and concomitant anticyclonic curvature tended to inhibit precipitation from the Dakotas eastward through the Great Lakes. The two weak mean troughs in the eastern third of the country (one in the Southeast and the other off the east coast) served only to provide a clue toward a complex rather than a simple precipitation pattern in this broad area.

In a gross sense the low-index pattern present during the month may be associated with the precipitation anomaly depicted on Chart III–B. The southward displacement of the mid-tropospheric jet stream (fig. 3A) was effective in transporting more moisture than normal from the Pacific into the Southwest and also in streaking moisture from the Gulf of Mexico eastward over the Southeast. At the same time, stronger than normal westerlies at low latitudes might have been expected to cut off the Gulf of Mexico as a moisture supply source for the region from the Central Plains eastward to the Atlantic Coast.

This same argument may be used to explain the highly anomalous character of the precipitation during the first ten months of 1957, mentioned in section 1.

3. TROPICAL ACTIVITY

During the past 70 years the Atlantic region, including the Gulf of Mexico and the Caribbean Sea, has averaged about two tropical storms per year in October, with about one of these reaching hurricane intensity [2]. One tropical storm did develop during the month, and its track may be found on Chart X beginning near 25° N., 60° W. on the 23d. Figure 9A is the 5-day mean chart at 700 mb., centered a day after the storm first made its appearance.

Six storms were observed over the tropical regions of the North Pacific during the month, with all six reaching hurricane (typhoon) intensity. Dunn [2] gives the normal October tropical storm frequency for the North Pacific as 4, with 3 occurring west of 170° E. and 1 off the west coast of Mexico. The increased tropical activity in the North Pacific this year was a reflection of greater than normal occurrence off the Mexican coast. This region has been unusually active throughout the season, but precise statistics regarding the total number of storms must await final tabulation. The increased activity was associated with the trough along the west coast of North America which has been rather persistent and well developed, especially at the lower latitudes, throughout the summer and fall seasons.

The tracks of the three storms which formed in the eastern Pacific may be found on Chart X. The first may have developed during September, as reported by Ballenzweig [1] in the previous article of this series. The second and third storms were generated during the latter half of October, and sparsity of data in the area necessitates the attachment of the label "preliminary" to their tracks and history. Apparently the storms passed near and over Mazatlan Mexico, although separated in time by only 24 to 36 hours and in space by only 60 to 80 miles. There is some evidence to indicate the first of the storms was dissipating rapidly before it passed inland.

Typhoons Irma, Judy, and Hester comprised the extent of the tropical cyclogenesis in the western Pacific during October, but tracks for these storms are not reproduced here. Irma developed west of the Philippines about the 9th and moved westward through the South China Sea, reaching typhoon intensity before passing inland over Indochina.

Hester was detected as a tropical storm on the 5th near 11° N., 145° E. It moved in a northerly direction during its life history, reaching typhoon intensity for at least 2 days before developing extratropical characteristics near 40° N., 150° E. some 350 miles east of Japan.

Judy was first detected as a typhoon on the 22d about 5° north of the position first given for Hester. The track followed by Judy, however, was northwest for about 48 hours, followed by recurvature just west of the 135° E. meridian, skirting about 150 miles east of the Japanese islands. The storm developed extratropical characteristics by the 26th in the area east of Japan and continued eastward and then northeastward across the Pacific as a well-developed system, finally becoming absorbed in the Aleutian Low.

4. FIVE-DAY MEAN CIRCULATIONS AND WEATHER OVER THE UNITED STATES

Data contained in table 1 denote a trend, on the order of months, in the zonal index of the mid-latitude westerlies. These data illustrate, on a basis of 30-day mean statistics, that the index has been at, or below, its normal value for six consecutive months. Computations based on longer- or shorter-period means, while not invalidating the facts in table 1, would, of course, present a different picture

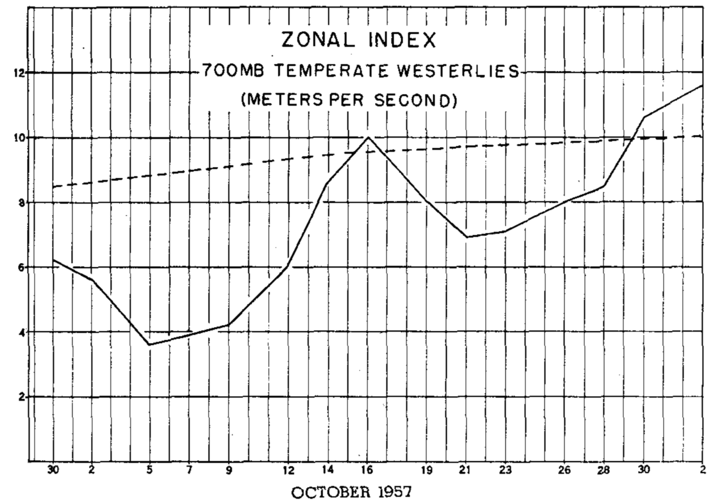

FIGURE 5.—Five-day mean zonal index of 700-mb. westerlies (35°–55° N.) for the Western Hemisphere, October 1957, with observed curve solid and normal dashed.

regarding the index. In routine extended forecasting a graph of 5-day mean index values (computed three times a week and plotted on the last date of the period) is prepared in addition to the 30-day index graph. The 5-day graph, as it applies to October, has been included here as figure 5 to assist in the discussion of the variations in the shorter-term mean circulations within the month.

Several conclusions regarding these variations can be obtained through this graph. It is evident from figure 5 that while the zonal index averaged below normal for October, it also underwent two oscillations during the month. Moreover, the trend of the index within the month was a return to more normal (higher) values.

FIRST WEEK

The 5-day mean circulation at 700 mb. for the period October 1–5 (figure 6A) represented the best developed low-index-type circulation of the month. The contour pattern with its large-amplitude waves and cut-off low centers at middle latitudes is characteristic of the classical low-index circulation. The DN field on this chart is even more expressive in depicting the interruption of the westerlies in mid-latitudes, with strong positive anomalies extending in a belt between 50° and 60° N. from the eastern Atlantic westward through the +500-ft. center in Canada to the +560-ft. center over the Alaskan Peninsula. A corresponding band of negative anomaly was found to the south, producing an easterly DN flow over much of the Western Hemisphere between 40° and 55° N.

The temperature and precipitation anomalies over the United States accompanying this classical low-index pattern are depicted in figure 6, B and C. The meridional orientation of the temperature anomaly, as well as its sharp gradient in an east-west sense, also fits the low index-large amplitude concept. The belt of above normal temperatures extending from New Mexico to the Dakotas was related to the mean ridge and its stronger than normal southerly flow shown in figure 6A. The colder than normal areas west of the Continental Divide lay under well below normal heights at 700 mb. as did the region east of the Great Plains.

Precipitation for the week as shown in fig. 6C was also related to the mean mid-tropospheric circulation of the week. The trough along the west coast, with its cutoff center over British Columbia, was effective in producing widespread precipitation over the West, although the dry weather over southern California is rather difficult to explain on this basis. Northerly flow and anticyclonic curvature at upper levels can be assessed as responsible for the precipitation void in the center of the country, while the cutoff Low in the Gulf of Mexico was responsible for the copious precipitation over the Southeast. Less precipitation over the Northeast may be related to the desiccating effect of the northwesterly and westerly flow dominating the region (fig. 6A).

SECOND WEEK

Rather spectactular changes in the 700-mb. circulation occurred during the second week of the month. Attention is directed toward a comparison of the DN fields in figures 6A and 7A in the area east of Greenland. The 610-ft negative anomaly centered near 60° N., 30° W. (fig. 7A) represents a deepening in this area of 830 ft. from the 5-day mean centered one week earlier.

Events leading to this deepening can be examined on a variety of time and space scales. The deepening was discussed on a broad-scale, monthly mean basis in section 1 and will now be related to the pattern of figure 6A. On this basis it is proposed that the deep polar vortex located near 80° N., 120° W., in association with the strong band of westerlies extending across northern Canada and Baffin Bay and the low center near 50° N., 50° W., provided shorter-term mechanisms necessary for the development of a strong baroclinic field just east of Greenland. Acknowledgement of a mechanism for development of a strong baroclinic field is not meant to deny barotropic support for the deepening which occurred.

The 5-day mean index of the zonal westerlies in the Western Hemisphere (fig. 5) responded to this deepening near Iceland as the westerlies increased at middle latitudes over the Atlantic.

No means for lowering the average temperature from the previous week by as much as 12° (compare figs. 6B and 7B) in the area east of the Continental Divide is readily discernible from figures 6A and 7A. At the surface was a strong polar anticyclone (see Chart IX) which moved southeastward from Alberta on the 7th and then slowly eastward across the northern part of the United States during the next 8 days. The contour pattern at 700 mb. (fig. 7A) provided an excellent steering current for this cold High, which, from the point of view of origin and slow movement, was sufficient to account for the sharp cooling over the Great Plains and the below normal temperatures observed over the country during this second week of the month.

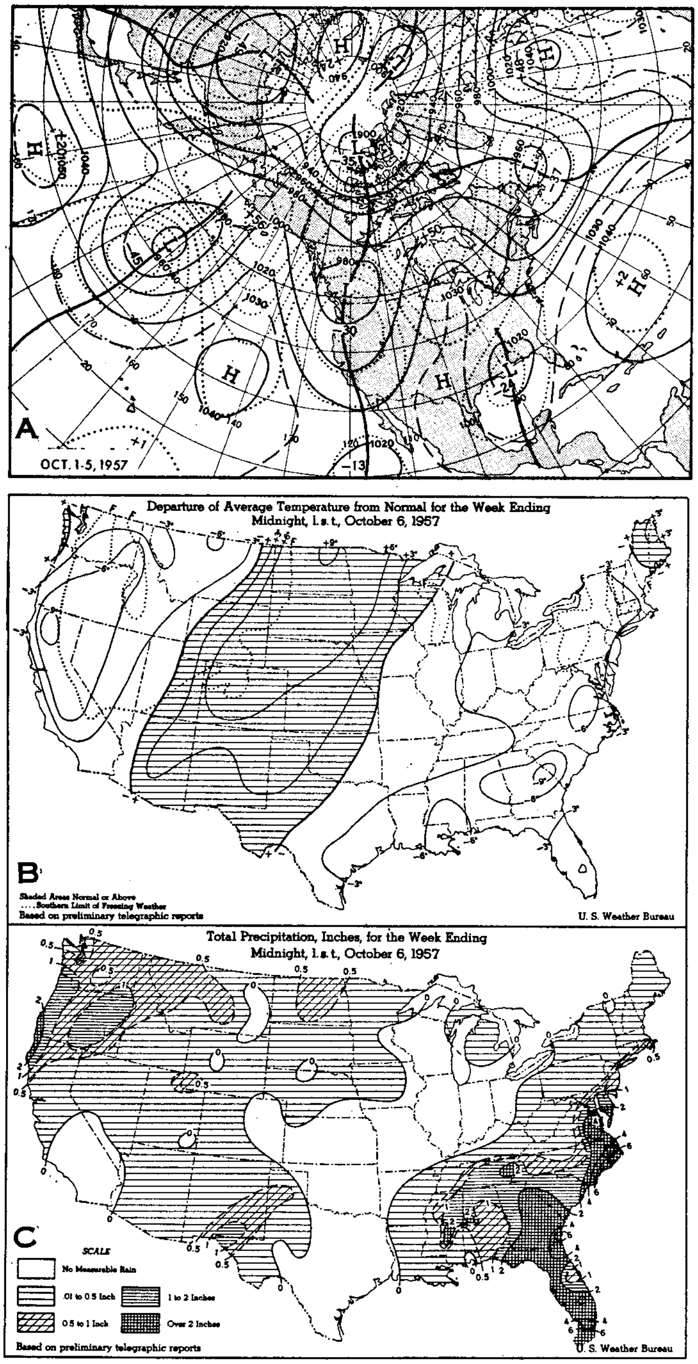

FIGURE 6.—Week ending October 5, 1957. (A) 5-day mean 700-mb. contours (solid) and departures from normal (dotted), both in tens of feet. (B) Surface temperature departure from normal (° F.). (C) Total precipitation (inches). B and C from *Weekly Weather and Crop Bulletin, National Summary,* vol. XLIV, No. 40, Oct. 7, 1957.

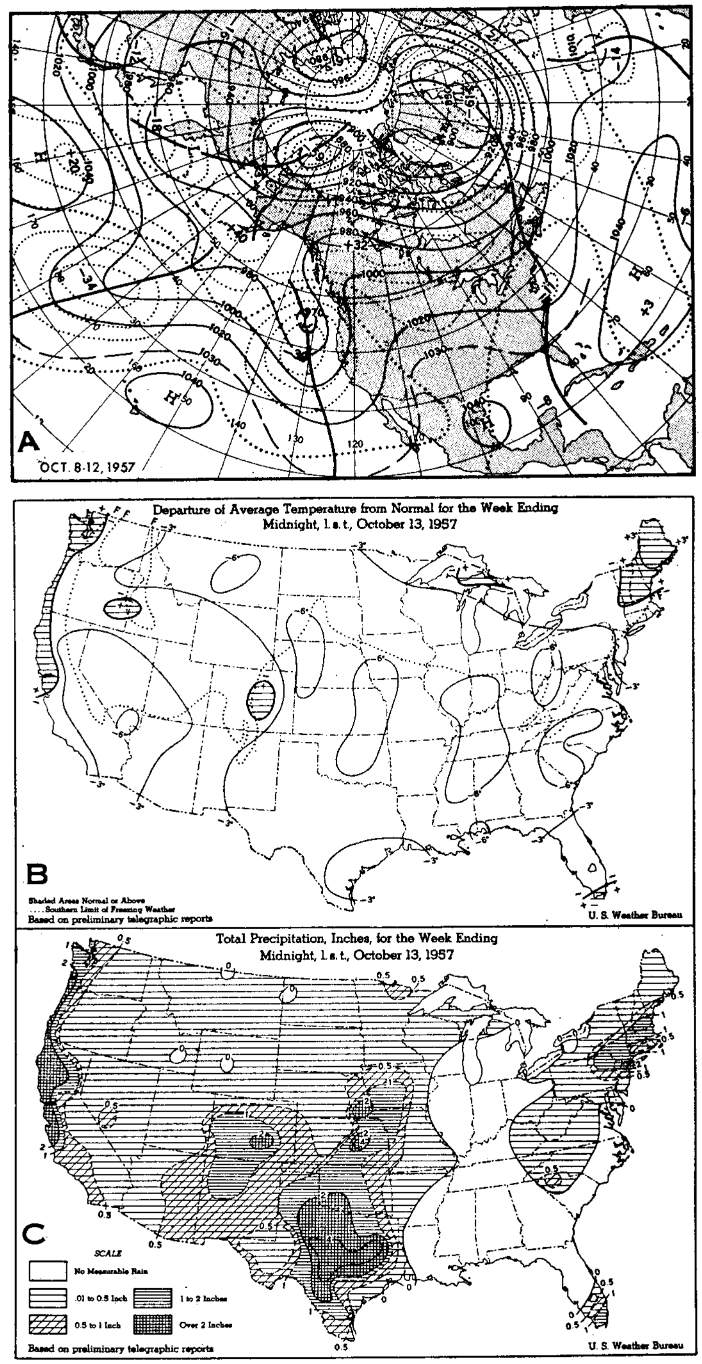

FIGURE 7.—Week ending October 12, 1957. (A) 5-day mean 700-mb. contours (solid) and departures from normal (dotted), both in tens of feet. (B) Surface temperature departure from normal (° F.). (C) Total precipitation (inches). B and C from *Weekly Weather and Crop Bulletin, National Summary,* vol. XLIV, No. 41, Oct. 14, 1957.

Heavy precipitation (fig. 7C) along the west coast can again be associated with the mean trough off the coast. The precipitation which occurred over New England was related to the mean trough at 700 mb. and the easterly DN flow over the area. The heavy precipitation in Texas was not related to the pattern portrayed in figure 7A but rather to a pattern which evolved from it. The heavy rainfall in this area fell on the 12–14th. Lack of concrete suggestions for heavy precipitation on a mean chart, centered 2–4 days earlier, points up some of the problems inherent in extended range forecasting in a rapidly evolving situation. In a daily sense, the precipitation in the Texas-New Mexico-Colorado region was produced as a frontal system moved eastward from the area of the mean trough shown off California on figure 7A. As it moved eastward a strong southerly current of warm moist air was advected northward from the Gulf of Mexico on the 10th and 11th. This system spawned at

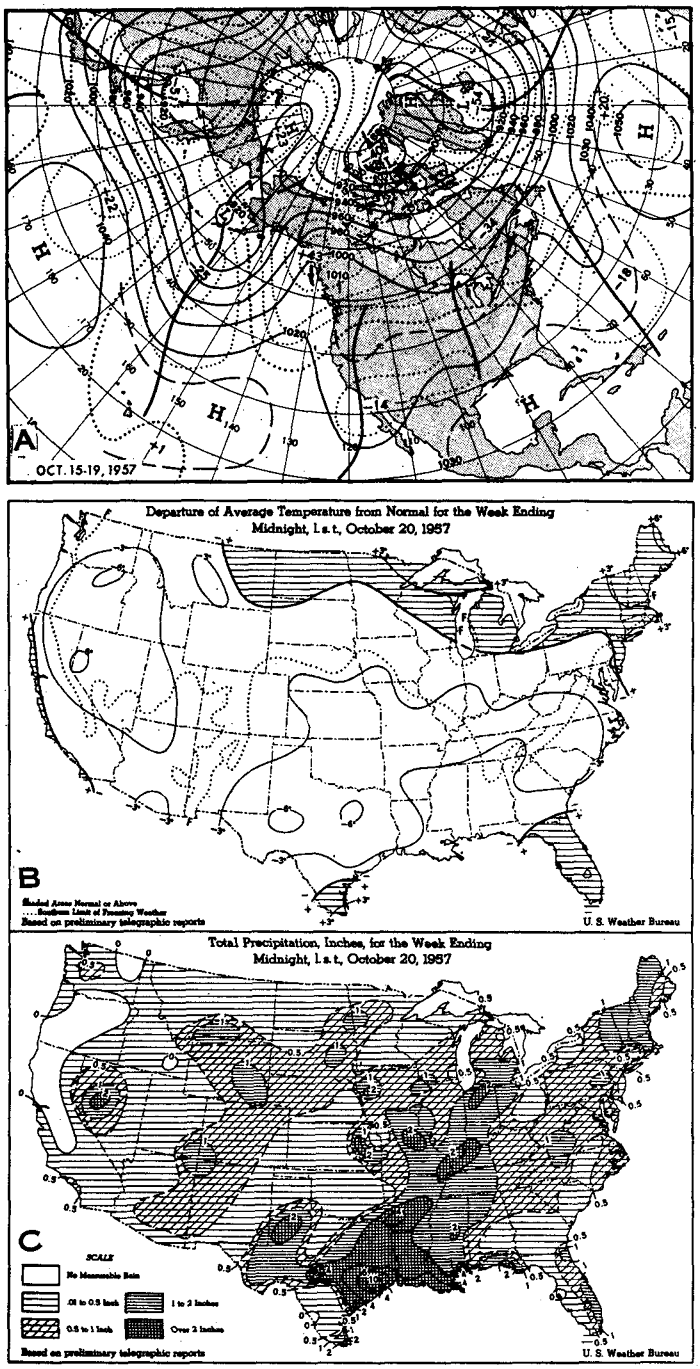

FIGURE 8.—Week ending October 19, 1957. (A) 5-day mean 700-mb. contours (solid) and departures from normal (dotted), both in tens of feet. (B) Surface temperature departure from normal (° F.). (C) Total precipitation (inches). B and C from *Weekly Weather and Crop Bulletin, National Summary*, vol. XLIV, No. 42, Oct. 21, 1957.

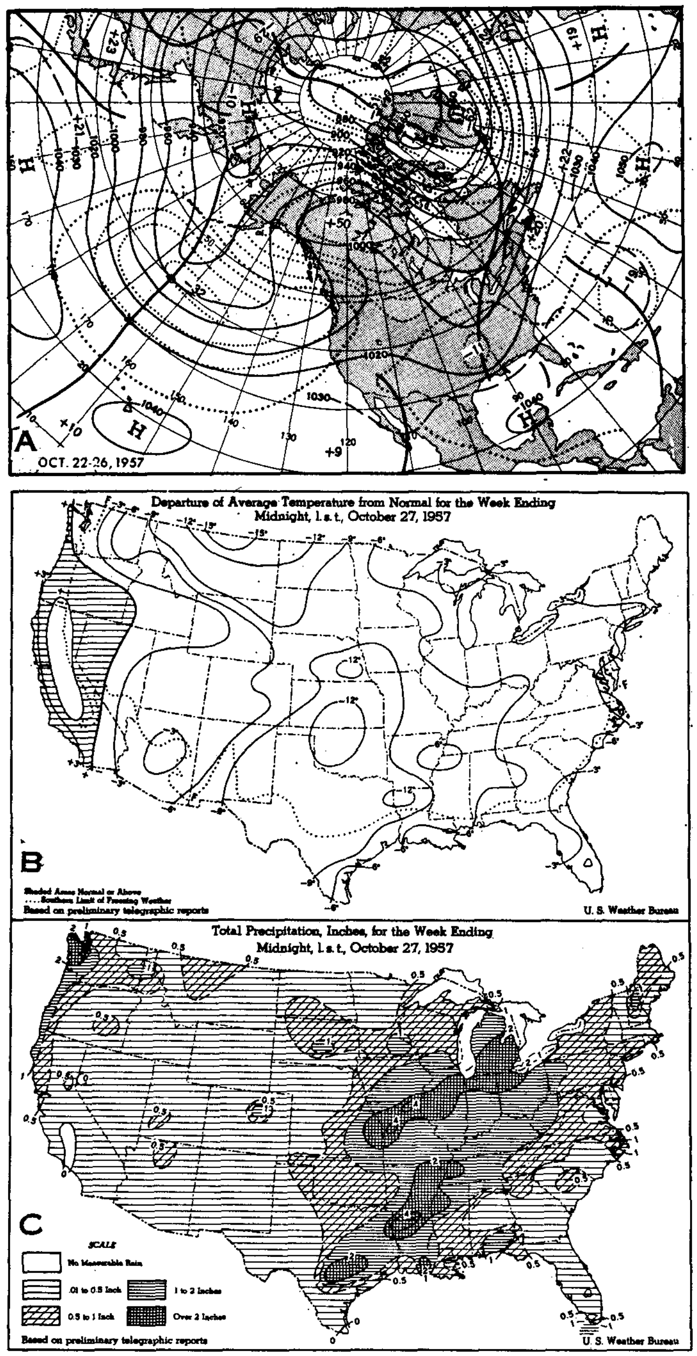

FIGURE 9.—Week ending October 26, 1957. (A) 5-day mean 700-mb. contours (solid) and departures from normal (dotted), both in tens of feet. (B) Surface temperature departure from normal (° F.). (C) Total precipitation (inches). B and C from *Weekly Weather and Crop Bulletin, National Summary*, vol. XLIV, No. 43, Oct. 28, 1957.

least one tornado on the 12th in New Mexico, two on the 13th in Texas and western Oklahoma, and still a fourth and fifth in Texas on the 14th as the daily trough system moved through the region.

THIRD WEEK

From figure 5 it can be seen that the second oscillation in the index of the zonal westerlies at 700 mb. began within the period of the 5-day mean chart presented as figure 8A. Positive height anomalies over Canada on this map were not materially different in either pattern or intensity from those shown in figure 7A. Intermediate-period 5-day mean DN charts (not shown) provide continuity for the +340-ft. center over eastern Canada and show that it was related to the +320 foot center over the Yukon in figure 7A. Similarly, the +430-ft. center just inland from the Gulf of Alaska can be tracked back to the +400 ft. center over the Alaskan Peninsula. This eastward rearrangement of the seat(s) of blocking over North America took place while the large negative anomaly center east of Greenland remained nearly stationary. Deepening of the Asiatic coastal trough and the dispersion of energy downstream may have provided the means for eastward motion of the DN features over North America.

Aside from the deepening in the Pacific, the most important feature of the mean circulation of the third week was the introduction of a new trough over the central portion of the United States, as the wave number over the Western Hemisphere increased from 4 to 5. This increase in wave number resulted in an unusually short wavelength over the country and was responsible for a change in the precipitation regime observed during the first two weeks. Rainfall in Illinois and Indiana, which had been almost nonexistent during the first two weeks, became heavy in many sections with the introduction of the new mean trough.

Precipitation amounts recorded in figure 8C present a rather complex pattern, but, in a general sense, the larger totals appear to be related to the mean trough positions shown in figure 8A. Absence of rainfall over Oregon and northern California was probably associated with easterly DN flow and therefore drier than normal air over the region, but the 2 inches or more which fell in central Nevada may have been a product of the cyclonic curvature in the contour field over the area. Heavy amounts in eastern Texas and the Lower Mississippi Valley can be attributed to the mean trough and weak cyclonic curvature at 700 mb., but the southeasterly flow at sea level on a 5-day mean basis (not shown) provided the moisture which the upper-level convergence acted upon.

Temperatures showed great stability in pattern from the second to the third week, but warming was evident from Montana eastward through the Great Lakes to the Northeast. The similarity of pattern and sign between the anomaly of temperature during this week and the departures from normal of 700-mb. heights (fig. 8A) was great over much of the country.

FOURTH WEEK

Intensification of the blocking characteristics of the mid-tropospheric circulation during the fourth week of the month was reflected by the 580-ft. positive anomaly center over the northern Yukon (fig. 9A). This center reached a peak intensity of +710 ft. about 8° farther west during the 5-day period October 19–23 (not shown), near the second minimum point reached on the index graph (fig. 5).

Adjustment in the wavelength over North America occurred with this increase in the intensity and amplitude of the contour ridge at 700 mb. (fig. 9A). This adjustment was reflected most clearly in the marked sharpening of the trough over the eastern United States and its northeastward extension to Greenland. The west coast trough weakened somewhat in response to stronger mid-latitude westerlies in the Pacific and the superposition of the ridge to the north.

The Atlantic coastal trough, which had been a full-latitude feature in figure 7A, and sheared and weakened in figure 8A, was suppressed farther southward in figure 9A as the westerlies increased sharply to the north. The tropical cyclogenesis mentioned in section 3 developed in this mean trough.

Daily systems associated with the major trough from Greenland to Louisiana (fig. 9A) combined to produce the coldest weather of the month over much of the country. Cyclogenesis occurred over Colorado on the 22d (Chart IX). Grace and Bohl discuss the unusual movement of an upper-level daily system prior to the time it became associated with the surface development in another article in this publication [3]. The surface system moved eastward on the 23d, causing widespread precipitation in the Ohio and Mississippi Valleys before passing out the St. Lawrence Valley on the 24th and 25th.

Polar continental air plunged southward behind this well-developed Low on a track suggested by the contours in figure 9A, but full effect of the polar outbreak is not indicated in figure 9C, because the period covered there ends at midnight on the 27th. Record-shattering minimum temperatures occurred on the 27th and 28th over the area from Texas to Florida, with a goodly number of the readings establishing new low marks for so early in the fall season.

Thus, the month ended with a display of highly anomalous weather. Such a display was quite in character with the abnormal pattern of the mean circulation of the month and, in fact, of the year of which it was a part.

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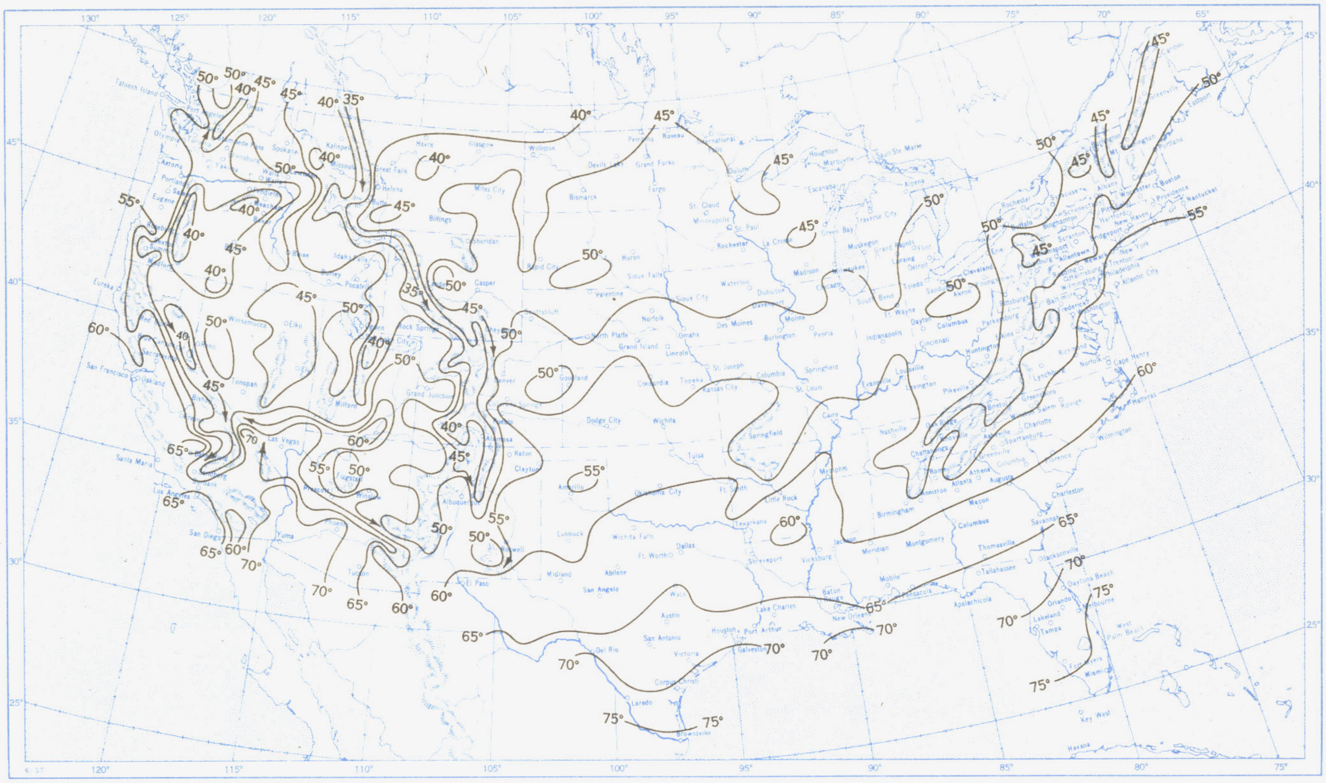
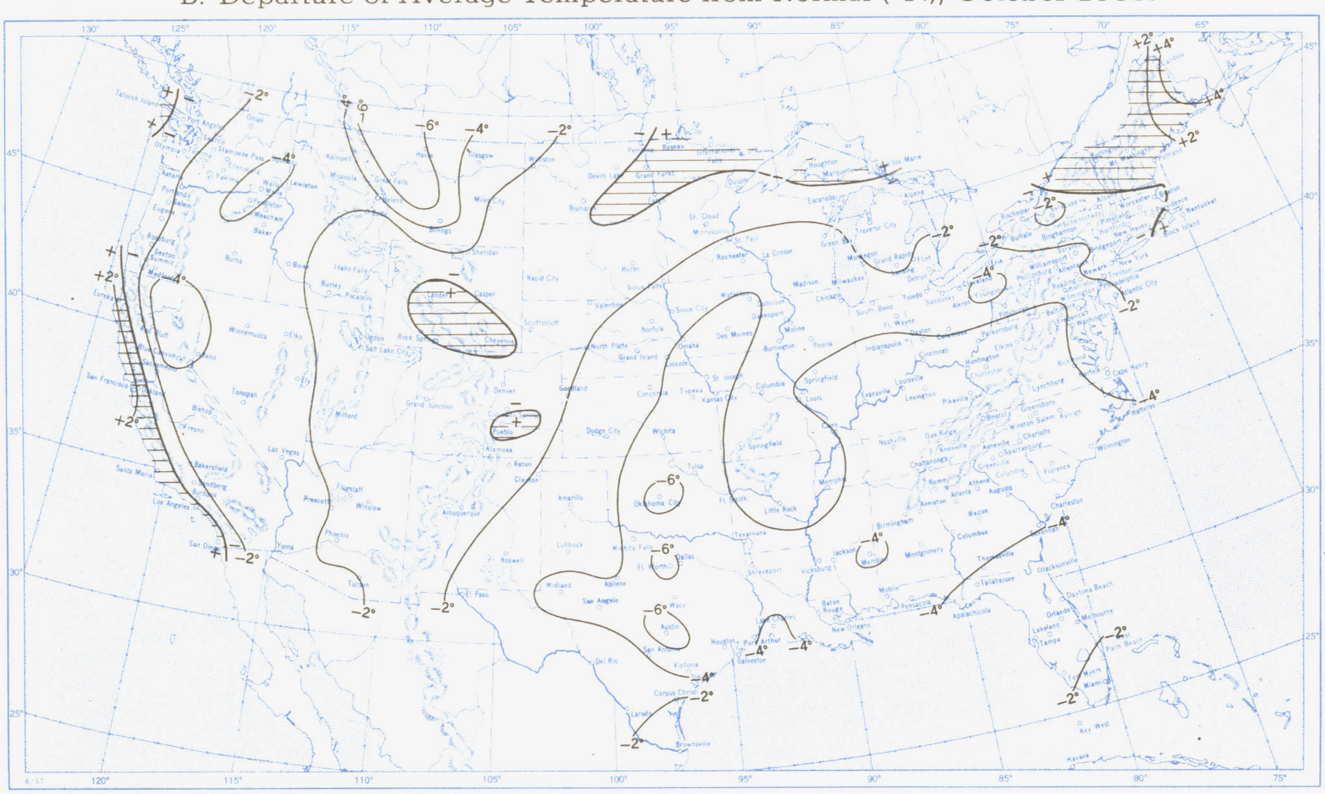
Chart I. A. Average Temperature (°F.) at Surface, October 1957.



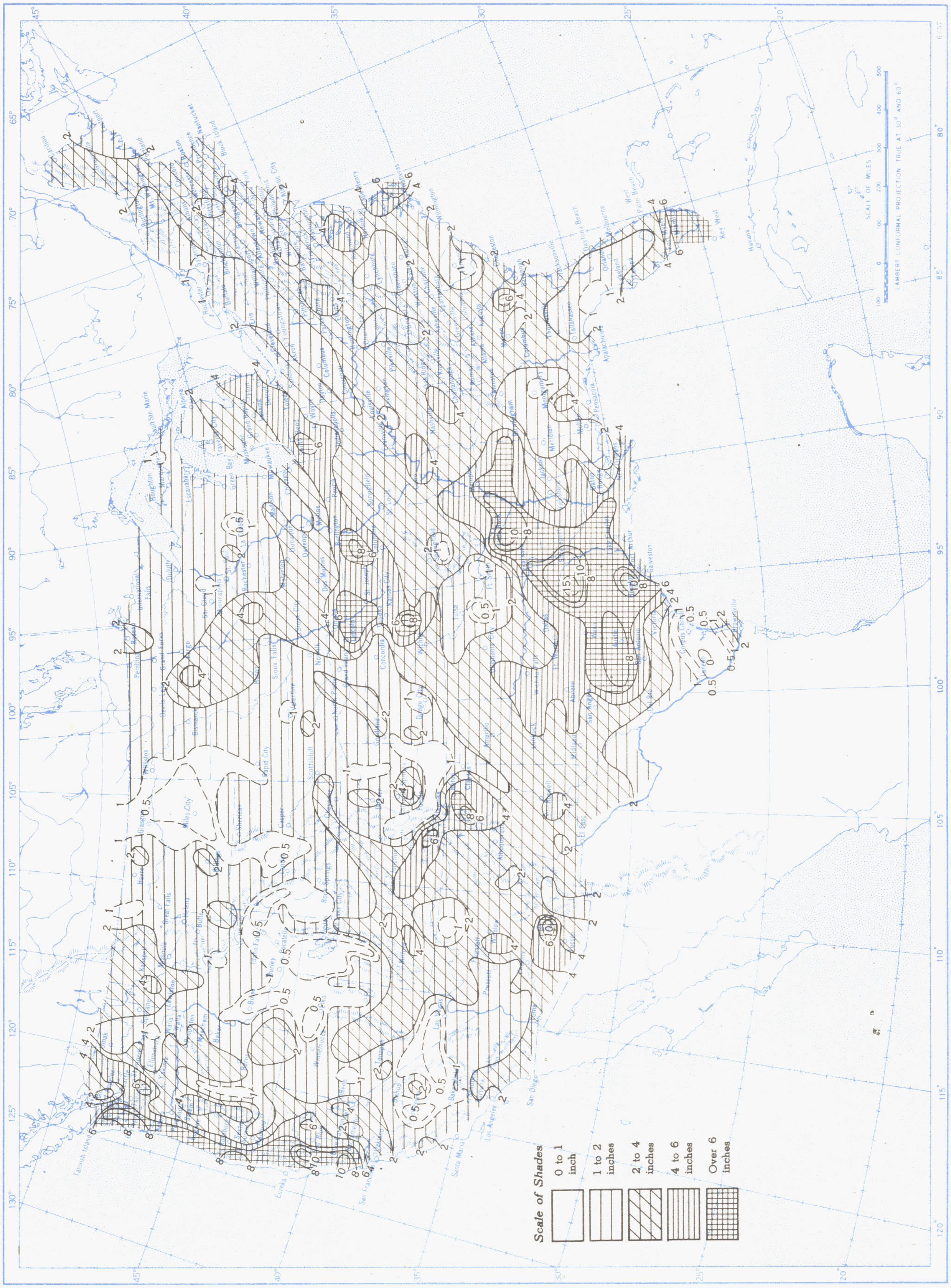
B. Departure of Average Temperature from Normal (°F.), October 1957.



A. Based on reports from over 900 Weather Bureau and cooperative stations. The monthly average is half the sum of the monthly average maximum and monthly average minimum, which are the average of the daily maxima and daily minima, respectively.

B. Departures from normal are based on the 30-yr. normals (1921-50) for Weather Bureau stations and on means of 25 years or more (mostly 1931-55) for cooperative stations.

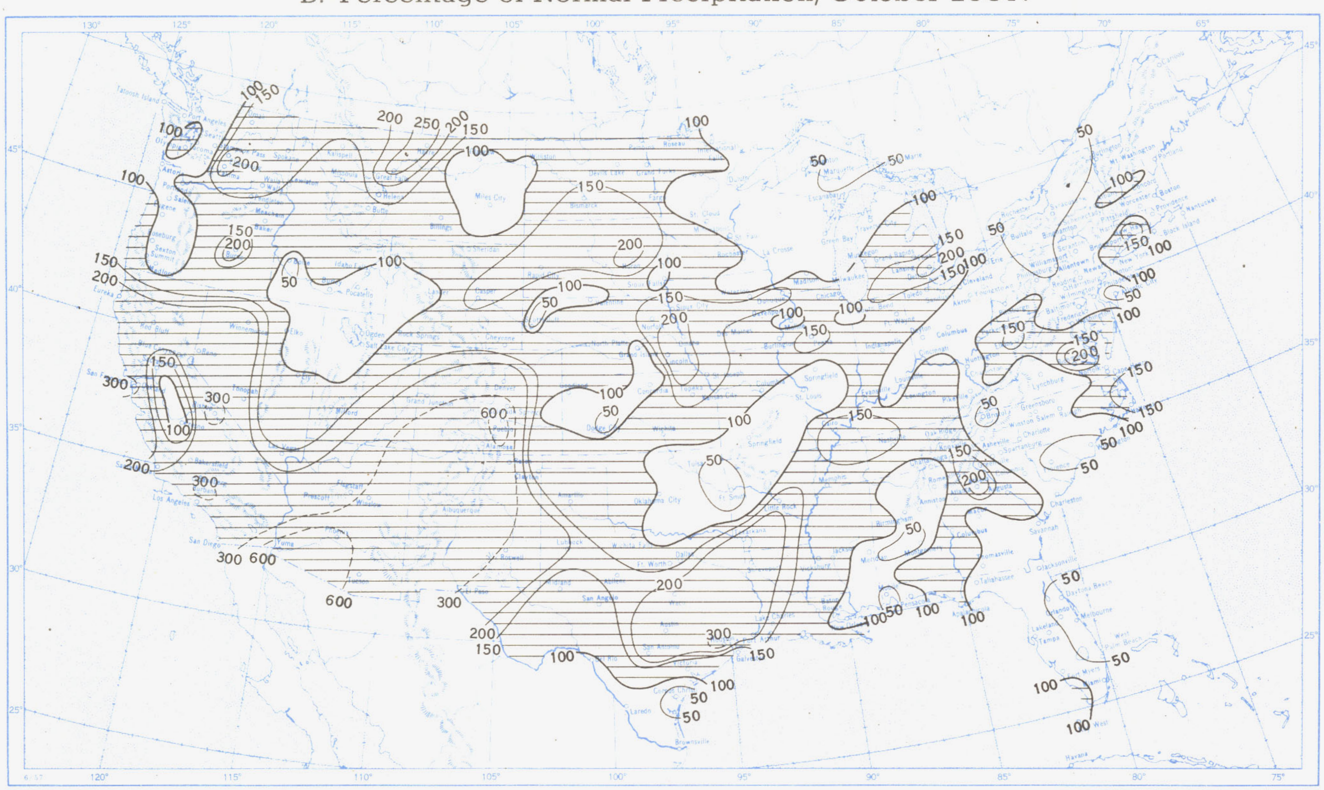
Chart II. Total Precipitation (Inches), October 1957.



Based on daily precipitation records at about 800 Weather Bureau and cooperative stations.

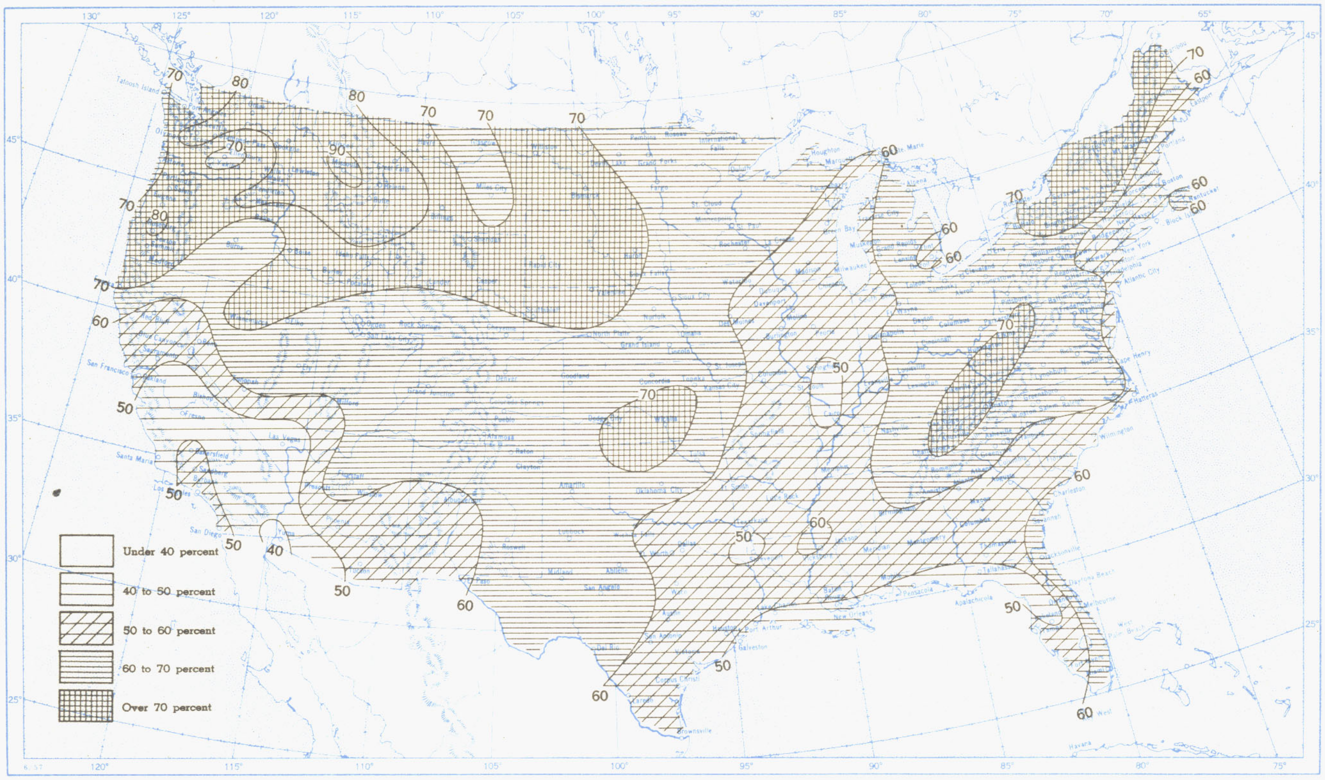
Chart III. A. Departure of Precipitation from Normal (Inches), October 1957.

B. Percentage of Normal Precipitation, October 1957.

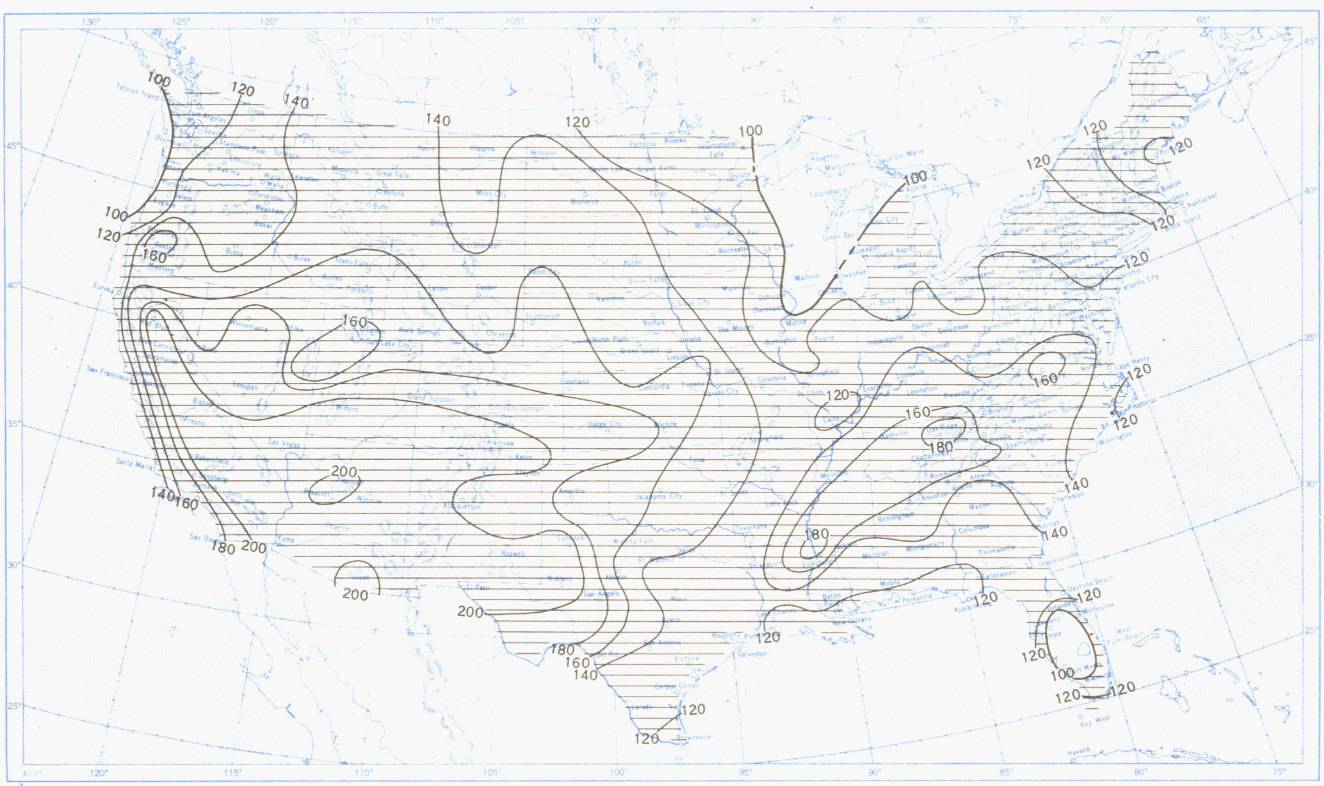


Normal monthly precipitation amounts are computed from the records for 1921-50 for Weather Bureau stations and from records of 25 years or more (mostly 1931-55) for cooperative stations.

Chart VI. A. Percentage of Sky Cover Between Sunrise and Sunset, October 1957.

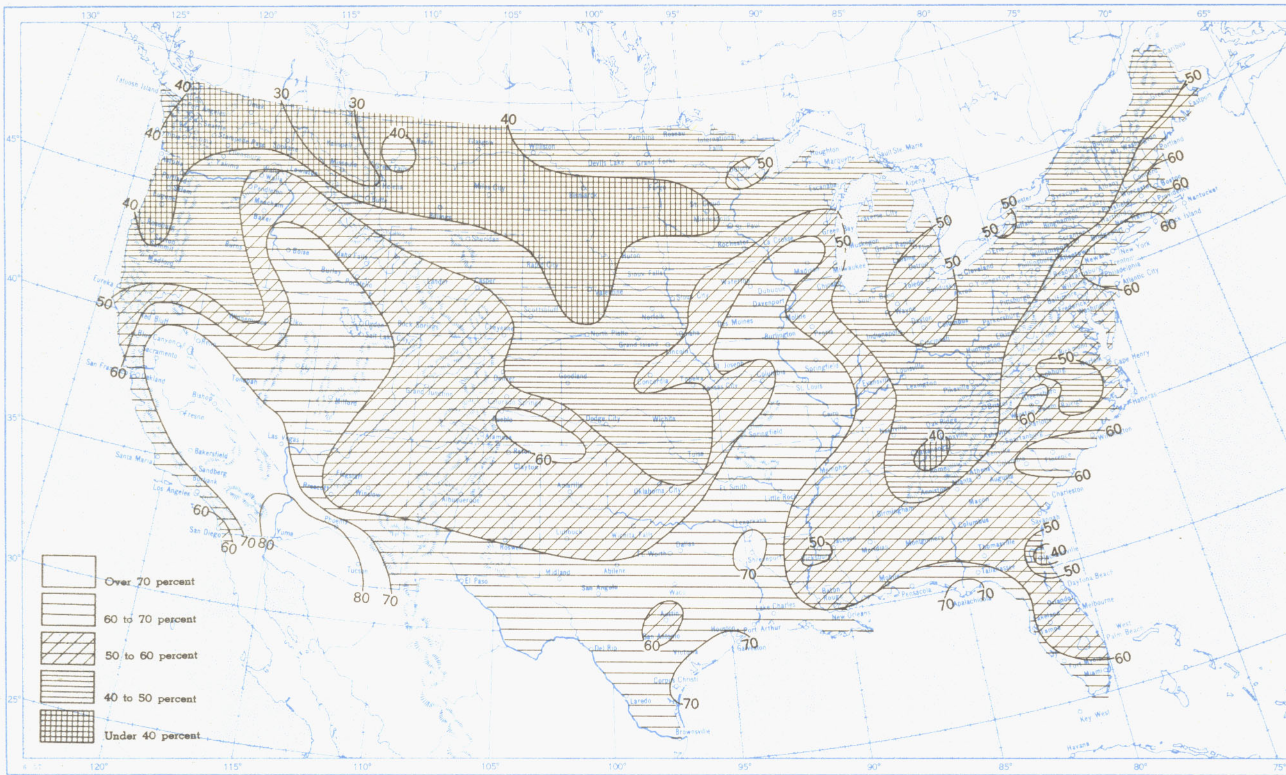


B. Percentage of Normal Sky Cover Between Sunrise and Sunset, October 1957.

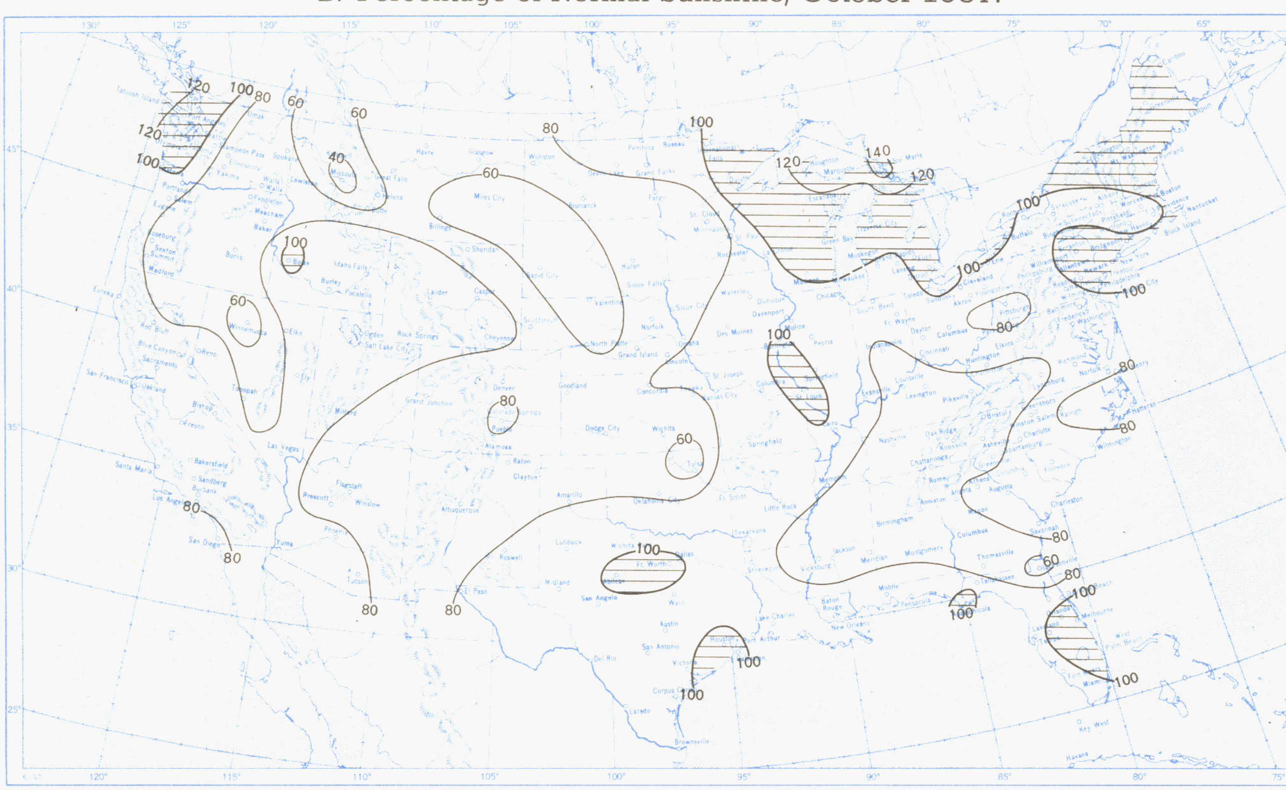


A. In addition to cloudiness, sky cover includes obscuration of the sky by fog, smoke, snow, etc. Chart based on visual observations made hourly at Weather Bureau stations and averaged over the month. B. Computations of normal amount of sky cover are made for stations having at least 10 years of record.

Chart VII. A. Percentage of Possible Sunshine, October 1957.



B. Percentage of Normal Sunshine, October 1957.



A. Computed from total number of hours of observed sunshine in relation to total number of possible hours of sunshine during month. B. Normals are computed for stations having at least 10 years of record.

Chart VIII. Average Daily Values of Solar Radiation, Direct + Diffuse, October 1957. Inset: Percentage of Mean Daily Solar Radiation, October 1957. (Mean based on period 1951-55.)

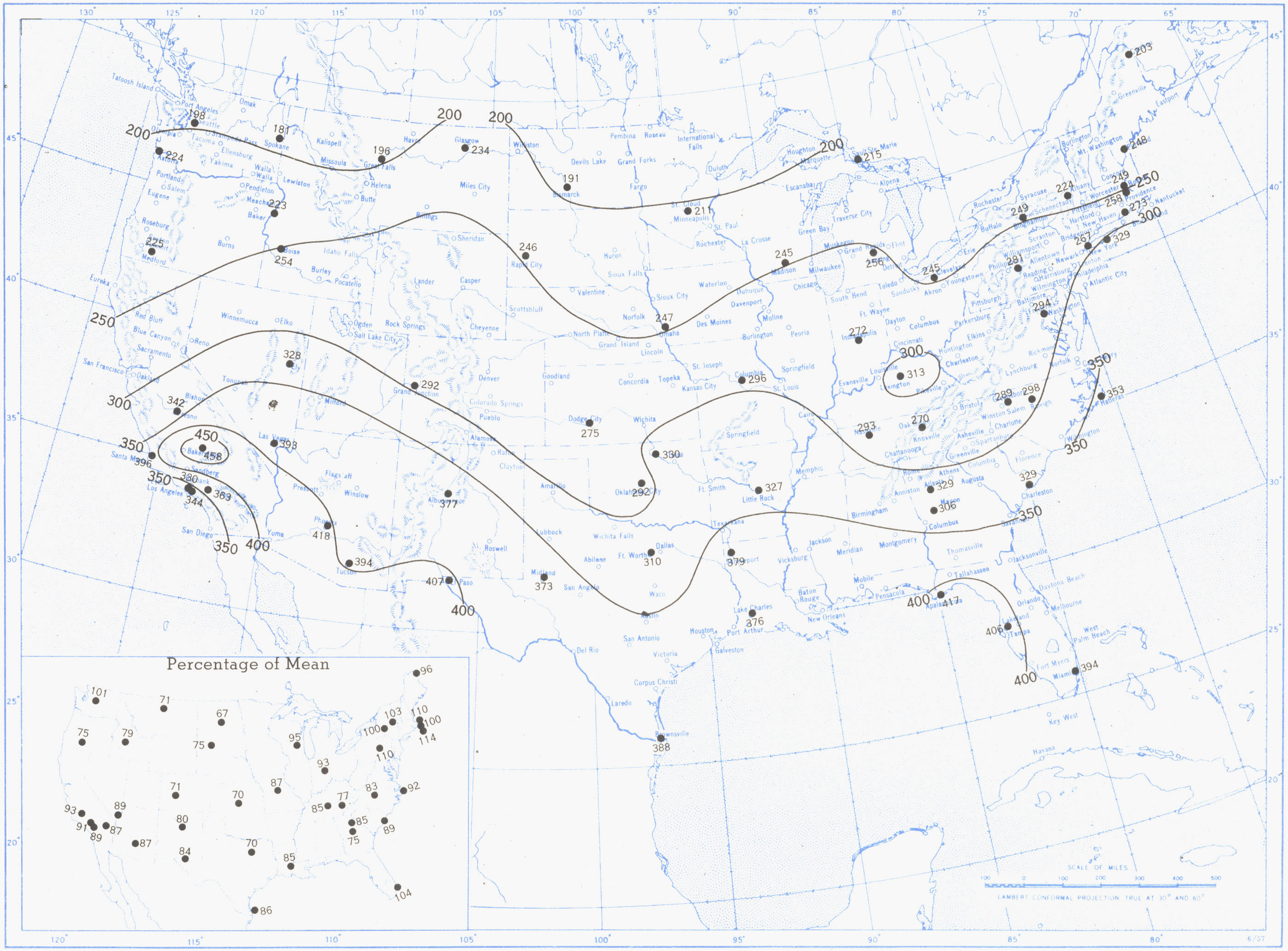
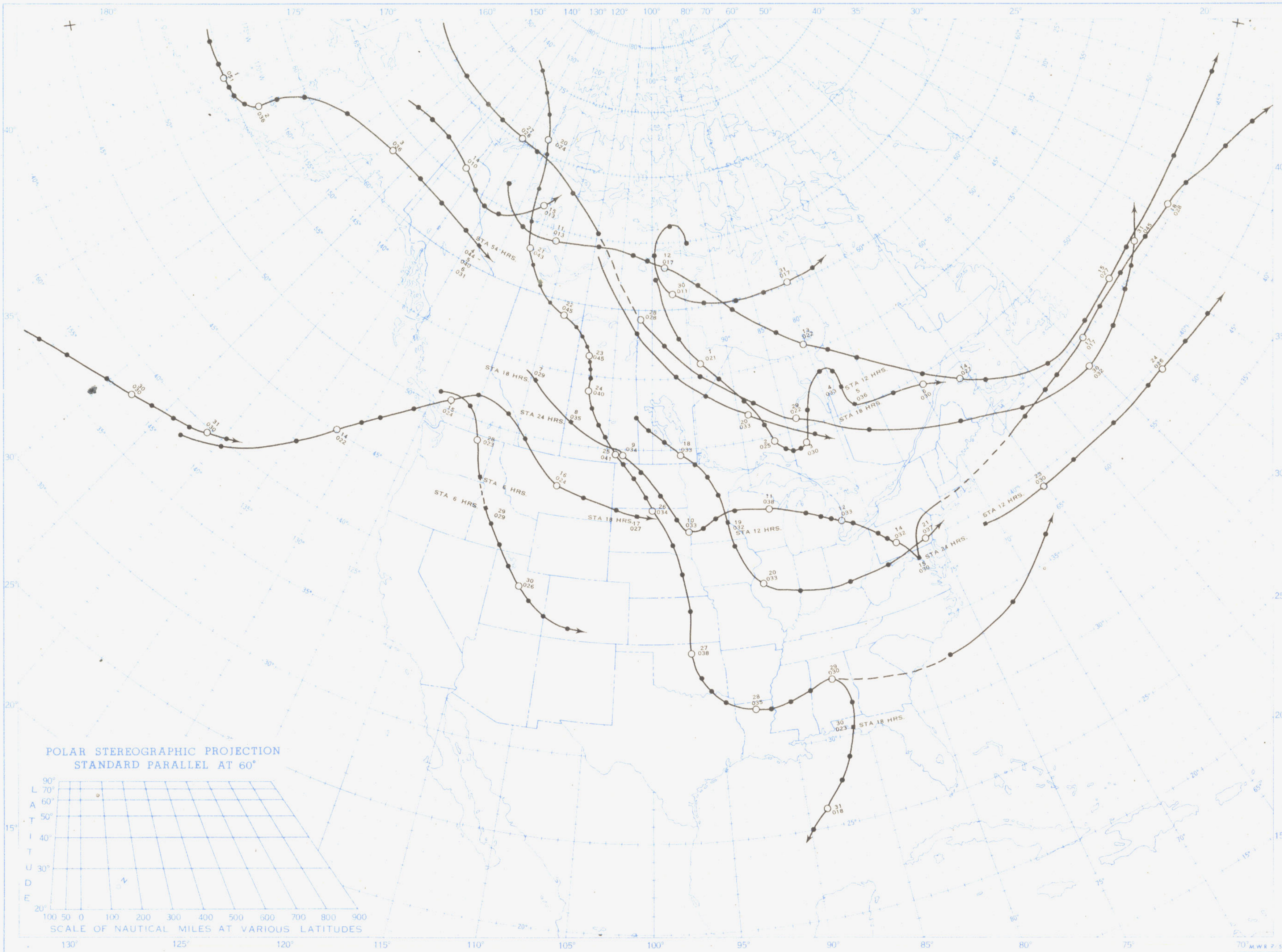


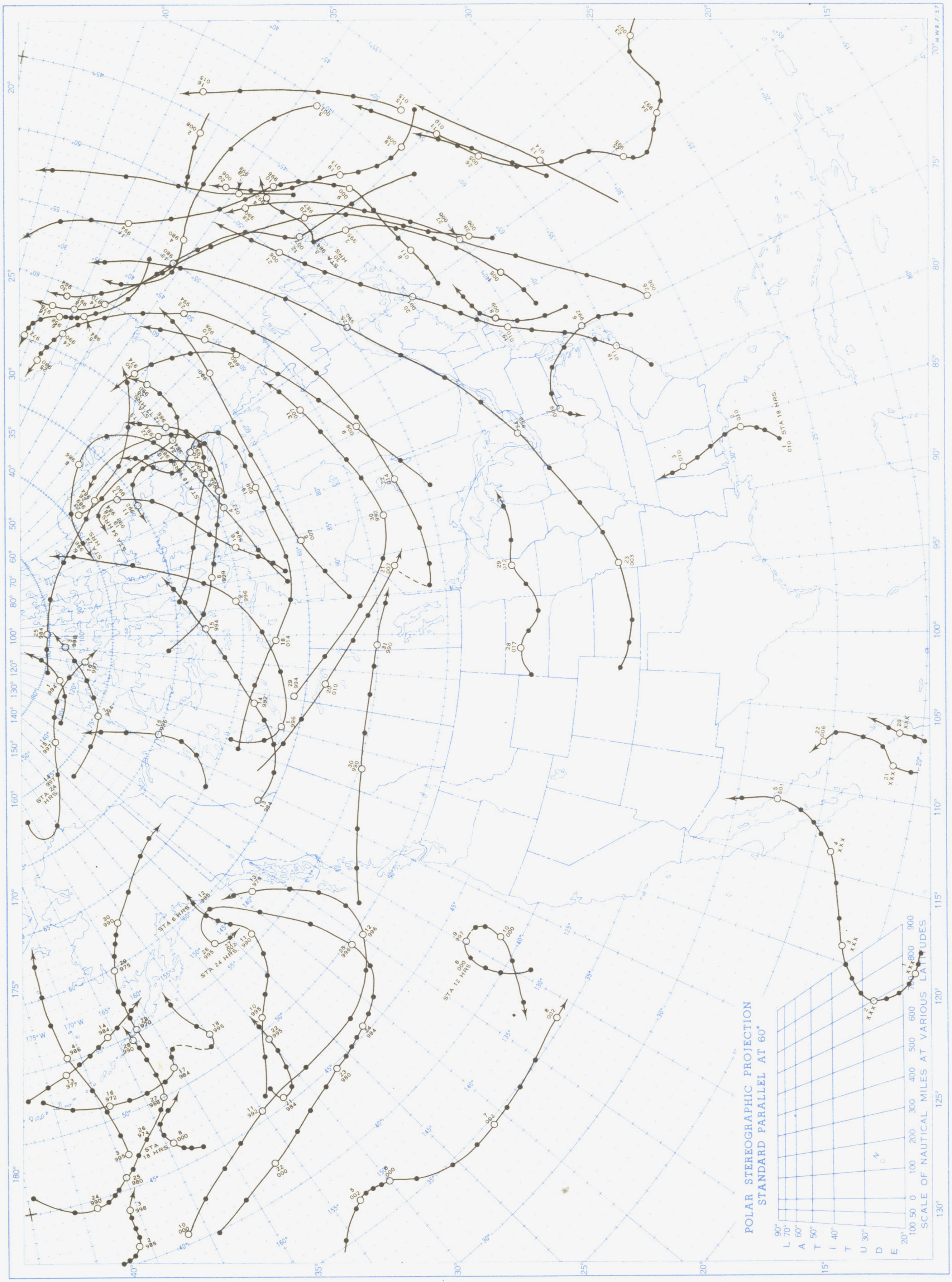
Chart shows mean daily solar radiation, direct + diffuse, received on a horizontal surface in langleys (1 langley = 1 gm. cal. cm. $^{-2}$). Basic data for isolines are shown on chart. Further estimates are obtained from supplementary data for which limits of accuracy are wider than for those data shown. The inset shows the percentage of the mean based on the period 1951-55.

Chart IX. Tracks of Centers of Anticyclones at Sea Level, October 1957.



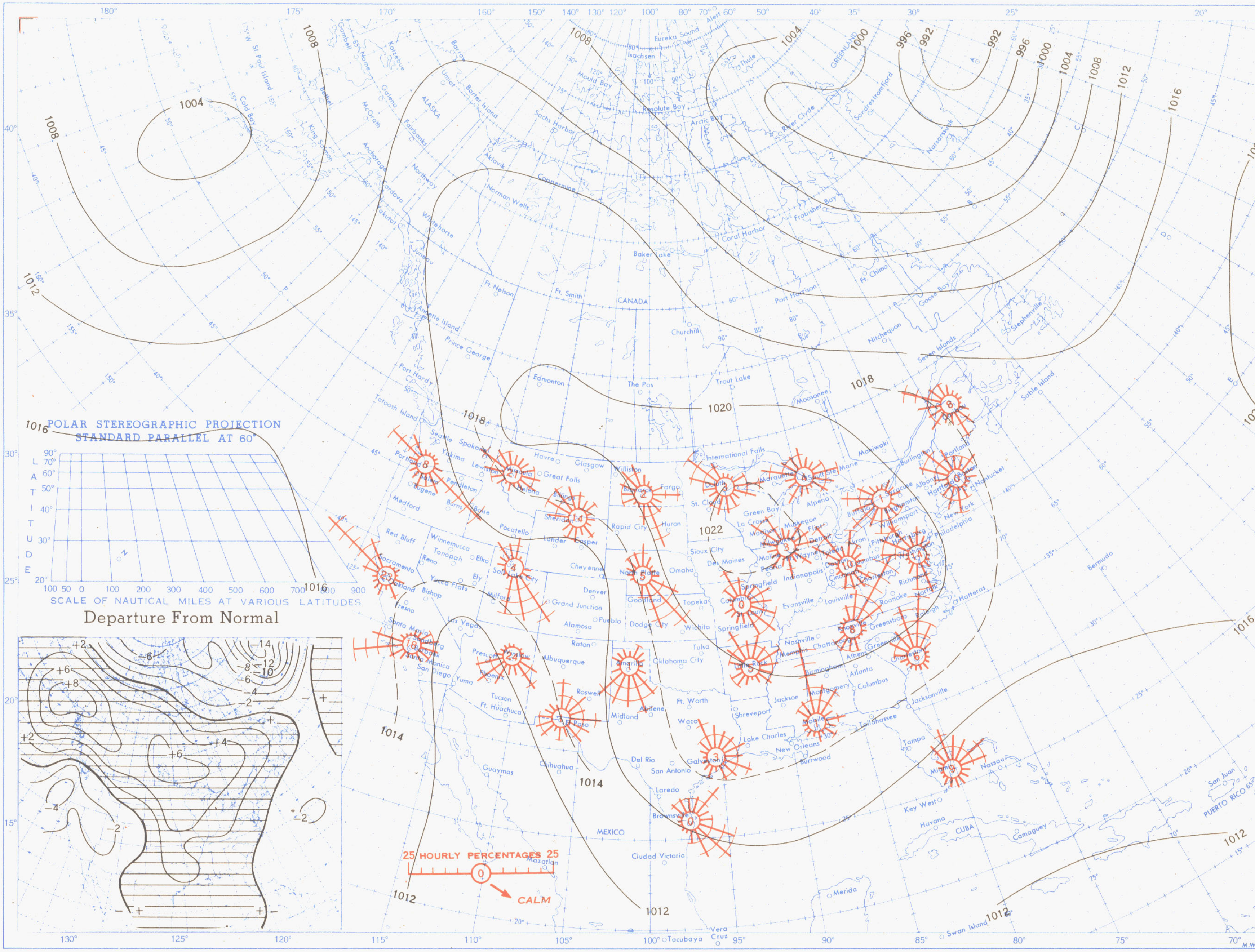
Circle indicates position of center at 7:00 a. m. E. S. T. Figure above circle indicates date, figure below, pressure to nearest millibar. Dots indicate intervening 6-hourly positions. Squares indicate position of stationary center for period shown. Dashed line in track indicates reformation at new position. Only those centers which could be identified for 24 hours or more are included.

Chart X. Tracks of Centers of Cyclones at Sea Level, October 1957.



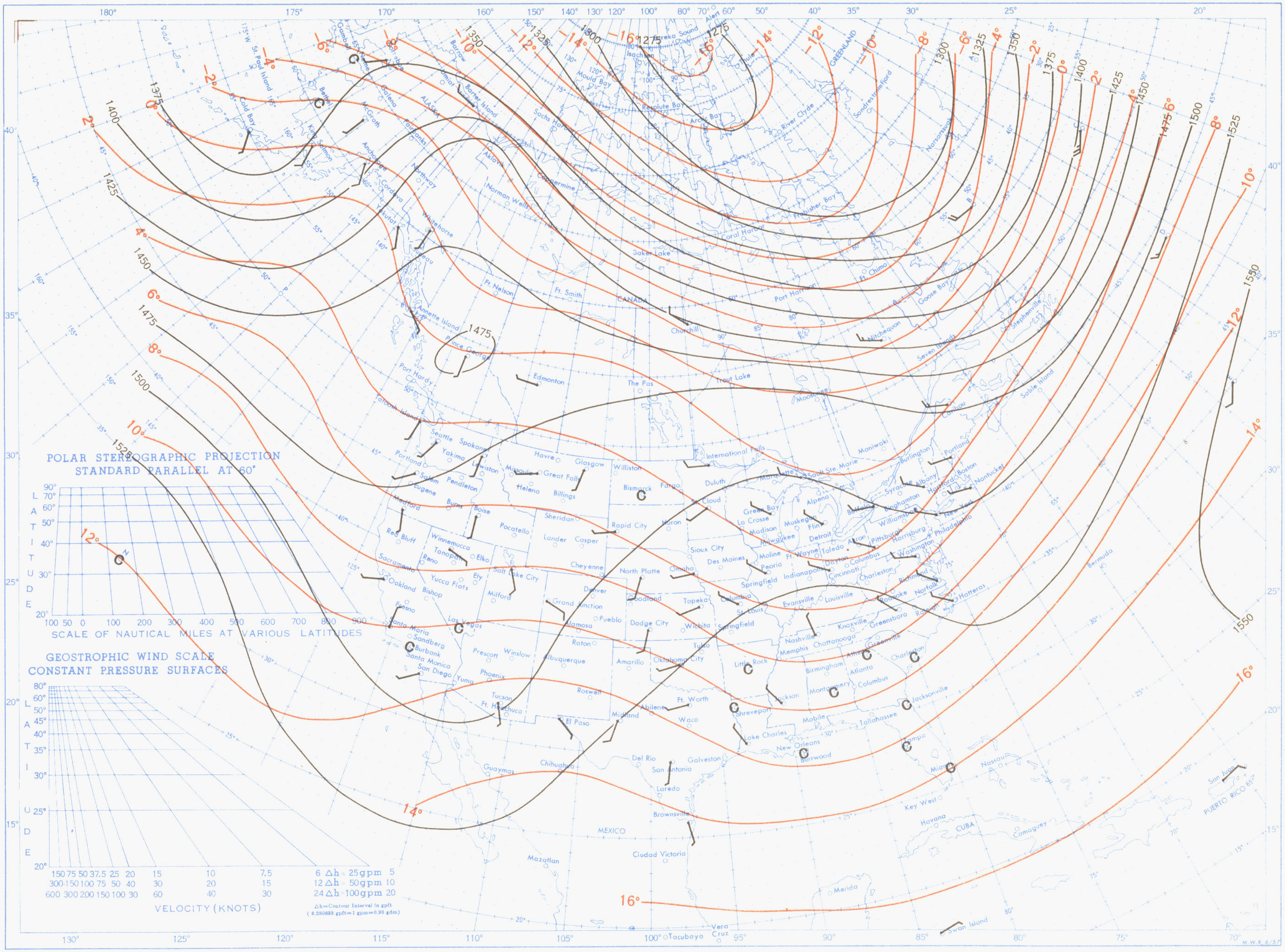
Circle indicates position of center at 7:00 a. m. E. S. T. See Chart IX for explanation of symbols.

Chart XI. Average Sea Level Pressure (mb.) and Surface Windroses, October 1957. Inset: Departure of Average Pressure (mb.) from Normal, October 1957.



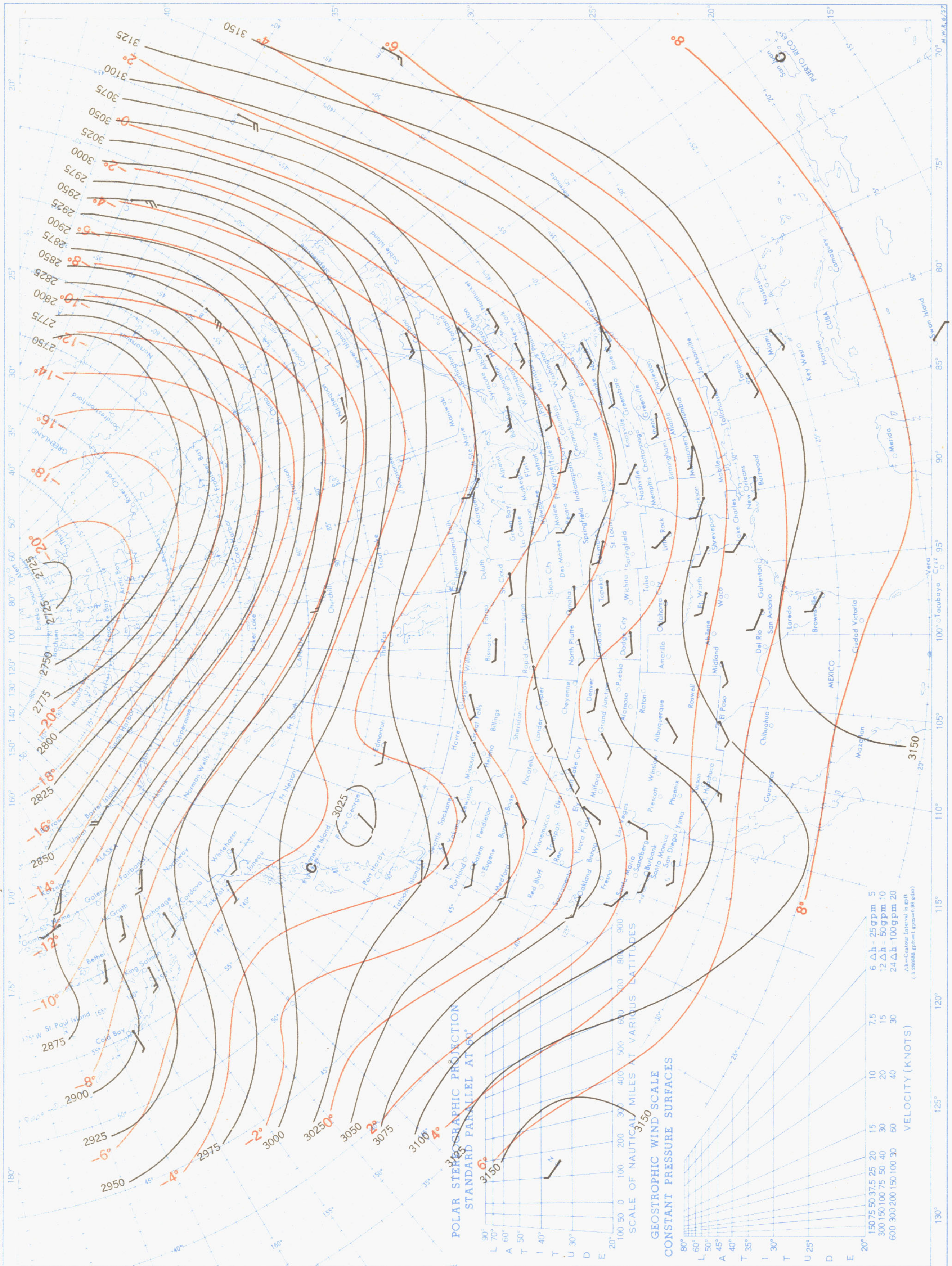
Average sea level pressures are obtained from the averages of the 7:00 a.m. and 7:00 p.m. E.S.T. readings. Windroses show percentage of time wind blew from 16 compass points or was calm during the month. Pressure normals are computed for stations having at least 10 years of record and for 10° intersections in a diamond grid based on readings from the Historical Weather Maps (1899-1939) for the 20 years of most complete data coverage prior to 1940.

Chart XII. 850-mb. Surface, 1200 GMT, October 1957. Average Height and Temperature, and Resultant Winds.



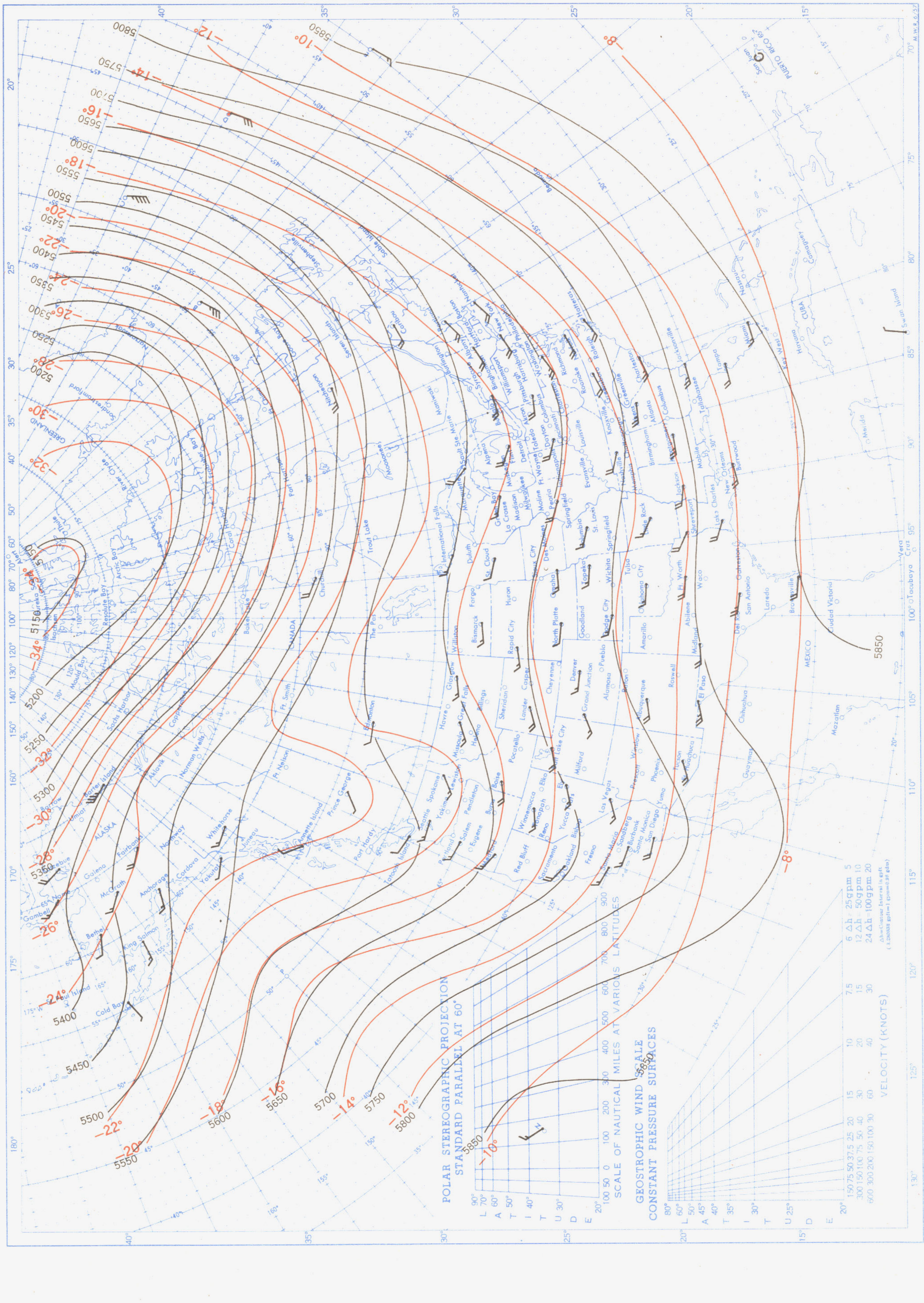
Height in geopotential meters (1 g.p.m. = 0.98 dynamic meters). Temperature in °C. Wind speed in knots; flag represents 50 knots, full feather 10 knots, and half feather 5 knots. All wind data are based on rawin observations.

Chart XIII. 700-mb. Surface, 1200 GMT, October 1957. Average Height and Temperature, and Resultant Winds.



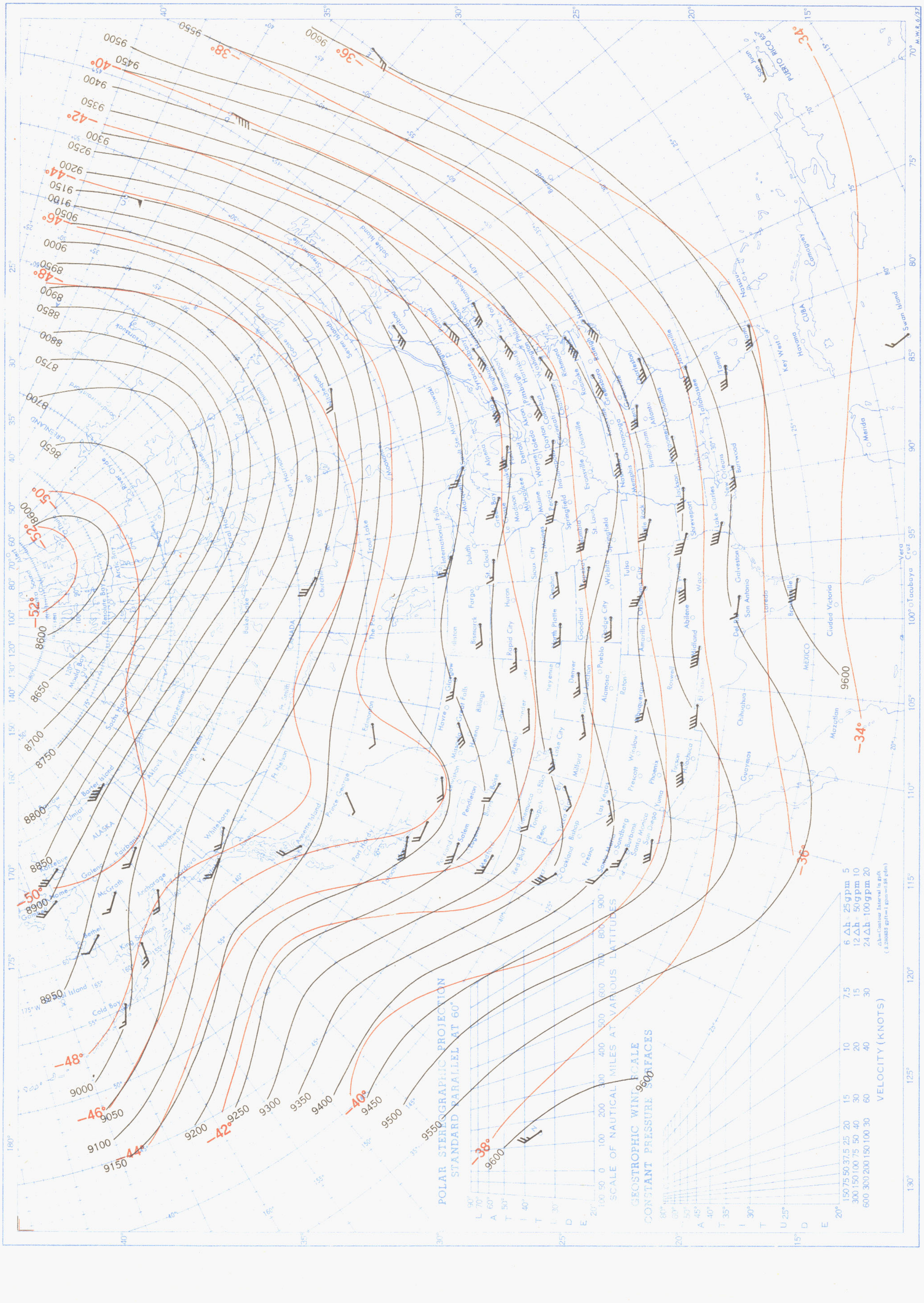
See Chart XII for explanation of map.

Chart XIV. 500-mb. Surface, 1200 GMT, October 1957. Average Height and Temperature, and Resultant Winds.



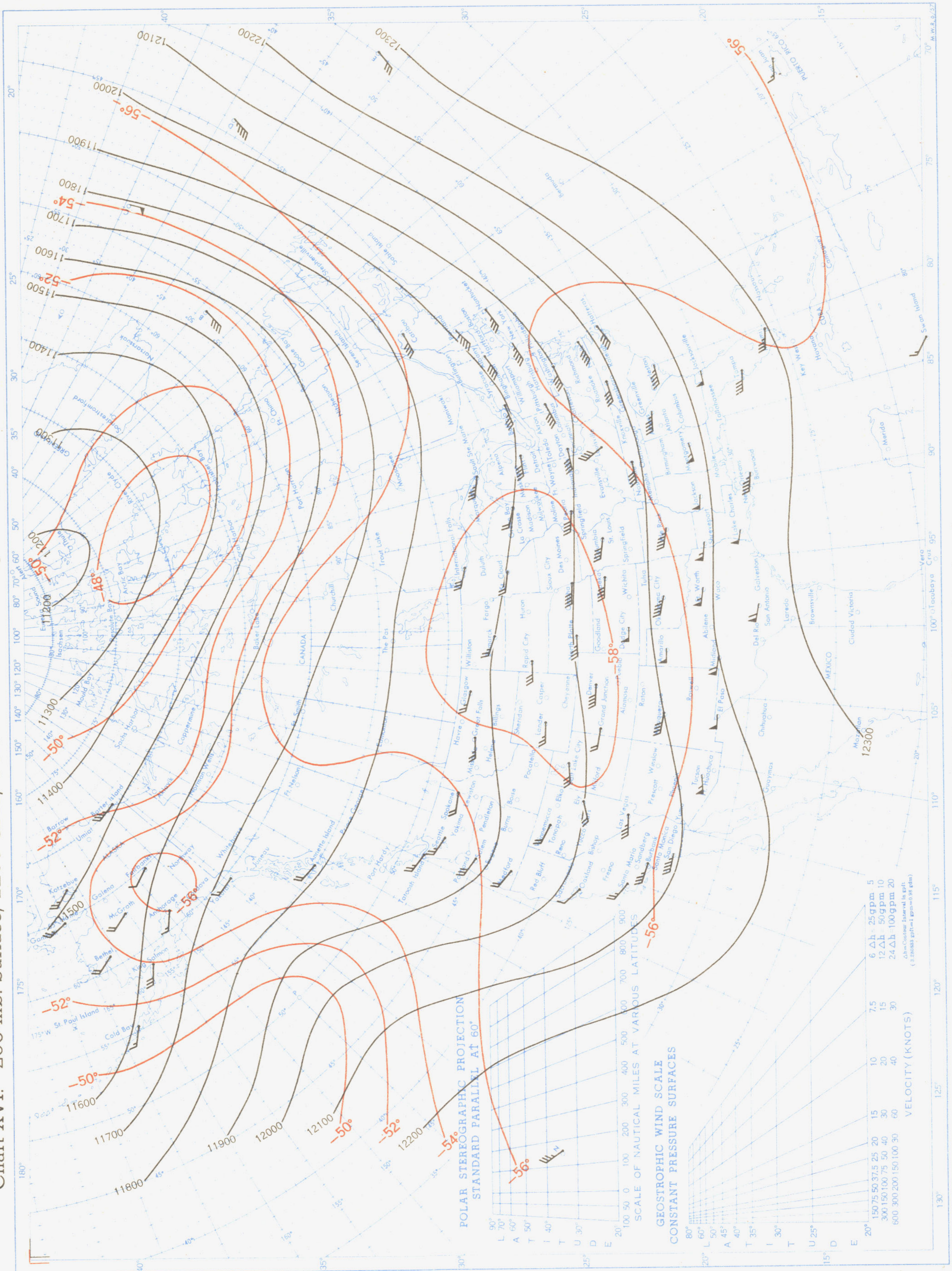
See Chart XII for explanation of map.

Chart XV. 300-mb. Surface, 1200 GMT, October 1957. Average Height and Temperature, and Resultant Winds.



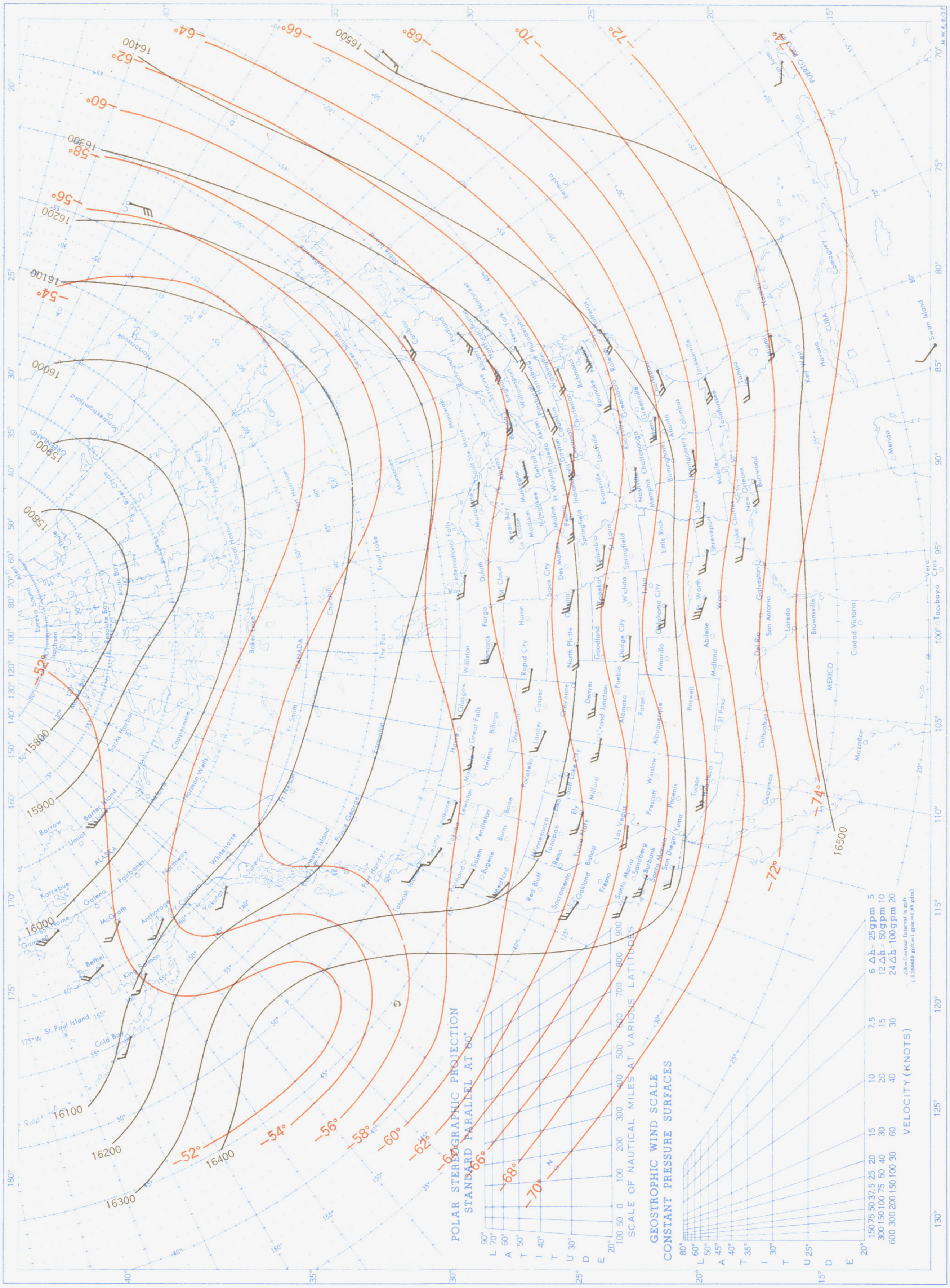
See Chart XII for explanation of map.

Chart XVI. 200-mb. Surface, 1200 GMT, October 1957. Average Height and Temperature, and Resultant Winds.



See Chart XII for explanation of map.

Chart XVII. 100-mb. Surface, 1200 GMT, October 1957. Average Height and Temperature, and Resultant Winds.



See Chart XII for explanation of map.